How does coursework based study affect the learning of pupils in secondary science education?

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Abstract

The GCSE science syllabus and curriculum changed considerably between 2005 and 2008. A key specification of coursework which had been identified as encouraging routine completion was replaced, requiring coursework to be completed under exam conditions, while a vocational alternative with increased coursework content was also introduced. I set out in this PhD study, as a 'researching teacher', to ascertain the attitudes of pupils and teachers to GCSE science coursework, and whether there exist any differences in pupil attainment linked to the reform of coursework and GCSE examination. I also have looked at how pupils learn in science through completing coursework as part of an evaluation of the effectiveness of coursework in the GCSE science curriculum. This thesis takes the form of a case study comprising reflecting a practitioner based enquiry using mixed methods methodology. It is therefore an integrated longitudinal design combining qualitative and quantitative methods. Qualitative data was elicited from interviews, questionnaires, observation and field notes. Quantitative analyses were undertaken of pupil performance in coursework and examination results.

Key research findings include confirmation that many pupils in the case study preferred a coursework based approach to their science education, and they found they learned more from this approach. Pupils were also found to prefer learning when a constructivist model of teaching and learning was adopted in the classroom. Active learning led to improvements in understanding and completing coursework. Additional analysis of quantitative data showed that many pupils achieved significantly better grades for their science coursework than they did through examinations. Further, the data revealed when coursework can be improved using an assessment-based approach to learning, and that there were no significant statistical differences between boys and girls in coursework and examination results. The research revealed that when coursework for GCSE science is reviewed and improved as part of a constructivist model of learning, there is a positive contribution to attainment levels in the GCSE examination. Furthermore, there is a need to consider how the format of that coursework ensure it does not encourage routine completion, but instead encourages assessment for learning, active learning and individual responsibility for learning. The thesis, overall, represents a personal, scholarly and professional engagement in understanding the work of teaching GCSE science.

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed......... .... Date...12TH AUGUST 2010...........

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Glossary of Abbreviations & Acronyms

AfL	Assessment for Learning
APU	Assessment of Performance Unit
AQA	Assessment and Qualifications Alliance
BBC	British Broadcasting Corporation
BTEC	Business and Technology Education Council
CASE	Cognitive Acceleration through Science Education
CPD	Continued Professional Development
CSE	Certificate in Secondary Education
DES	Department of Education and Science
DfES	Department for Education and Skills
FFT	Fischer Family Trust
GCE	General Certificate of Education
GCSE	General Certificate of Secondary Education
GNVQ	General National Vocational Qualification
ICT	Information and Communication Technology
ISA	Independent Skills Assessment
KS1/2/3/4	Key Stages One, Two, Three, Four
NAHT	National Association of Head Teachers
NC	National Curriculum
NCC	National Curriculum Council
OECD	Organization for Economic Cooperation and Development
Ofsted	Offices for Standards in Education
PSA	Practical Skills Assessment
QCA	Qualifications and Curriculum Authority
SATs	Standard Attainment Tests
Sc1	Science 1

SMA	Science Masters Association
UCR	University of California Riverside
UMS	Uniform Mark Scheme
UYSEG	The University of York Science Education Group

Chapter 1

Introduction and background to the study

1.1 Introduction

It occurred to me at regular intervals during my Masters degree research that the pupils who have to sit, listen, experiment and work through all of the changes in their GCSE science had little opportunity to express their views of what they have studied. Stenhouse (1975) shared similar sentiments, stating that if teachers listen to pupils' ideas and indicate that they take them seriously then this will boost pupil performance. Other researchers, including Benyon (1985), commented on a lack of emphasis on pupils' views in educational research. However, more recent studies, such as that by Toplis and Cleaves (2006), have been based on pupils' viewpoints, which offer a unique insight into the views of those to whom the changes in science education should ultimately benefit.

My intention through my research questions has been to discover the strengths and weaknesses of GCSE science coursework. This has included collecting and analysing the views of teachers and pupils towards science coursework and examination, investigating whether pupils perform better at coursework on examination in terms of academic results, and to ascertain how pupils learn whilst studying for these assessment techniques. I have also evaluated the impact of three science specifications; modular science, applied science and science 2006, on teachers, learners and their learning. The data I have collected and analysed in this thesis has been used to address these research intentions. My professional reasons for this thesis were to inform the work of colleagues and myself so that we could deliver the most relevant and suitable science courses. This could impact on the school as a catalyst to improving learning in science.

When I started this thesis, I was a teacher of science with six years of classroom experience in the UK secondary comprehensive system, teaching a variety of science specifications to General Certificate of Secondary Education (GCSE) level. Prior to commencement, I accepted a responsibility for vocational education with a remit for introducing GCSE applied science to raise the attainment of 'middle band' pupils; those projected to achieve grade D-E at science. I wrote my masters dissertation on this topic, which formed a springboard for the research described in this thesis.

1.2 Background

'Science education is dominated by one theme at the moment: curriculum change' (Charlesworth 2007 p.3)

In spite of a trend of increasing grade C passes in science whereby in 1984 only 20% of school leavers achieved grade C or above, but by 2002 this had risen to over 50% (Nicolson and Holman 2003), the science curriculum in England and Wales from 2005-8 was in a state of flux, and failed to engage young people (Osborne 2008). Most students up until the late 1980s studied the three separate sciences of biology, chemistry and physics as GCSEs. Coursework provided a small part of these qualifications (Jenkins 2004). The first change was to squeeze the three sciences into two GCSEs with two or more associated coursework investigations. In 2002 applied science was introduced to run alongside double science. This qualification was a radical departure from past qualifications with an emphasis on coursework rather than studying for examinations. In 2006 the science curriculum changed with the introduction of science 2006. Students now studied a core science made up of physics, biology and chemistry elements that count for one GCSE. In addition, they could opt for additional science, a second GCSE, which could be an applied coursework-based qualification, a mixture of the three sciences, or a specialist discipline such as astronomy. Coursework was changed to a series of laboratory-based assessments, to be completed throughout the year. Many schools also reintroduced separate science GCSEs to challenge their more able pupils. Heaton (2006) writing about one case study school described how the separate sciences were used in this way, with many separate science students continuing to study advanced level science courses. Alongside GCSEs, parallel coursework based qualifications, such as Business and Technology Education Council (BTEC) awards exist and became popular with some schools and pupils. These qualifications are beyond the remit of this thesis, which concentrates solely on the GCSE.

This constant change of curricula placed a lot of pressure on teachers to plan and teach successive year groups of pupils who may have been studying different content, which was assessed in different ways. Lower levels of confidence in GCSE science teachers than those working with younger age groups were reported on by The Council for Science and Technology (2006). In response to these changes, it was important to me as a teacher having to manage, teach and assess a changed curriculum to ascertain the attitudes and perceptions of teachers, and pupils to the coursework that they work with.

At the onset of this research, in the autumn of 2005-6, the issue of school coursework was making regular entries in both the education and mainstream press. The British Broadcasting Corporation (BBC) education website (2005a, b, and c) carried articles with such titles as 'Coursework in last chance saloon' and 'blatant copying' in coursework'. Yet, the House of Commons select committee for Science and Technology (2002) stated that 'it is important to assess practical skills at GCSE through coursework' (p.33) and the Biosciences Federation recommended more practical and investigative work in the school science curriculum (Reiss 2006). Osborne (2004) bemoaned how science coursework had been whittled down to three investigations that barely covered the range of skills and scientific practices and were seen by teachers and pupils as a waste of time. He stated that assessment was putting pupils and teachers off science, but did not reveal the evidence base for this statement. Science pupils obtaining grades they did not deserve due to plagiarism was criticized in The Times (2007a). Grayling (2006) added that parents tend to state how much help they give their sons and daughters with coursework, which has a distorting upward effect on grades (but not on actual achievements, since the pupils have not done all the work themselves). He linked this to a lowering of standards in schools. By the autumn of 2006 the Education Secretary announced the ending of GCSE coursework in mathematics to stop internet plagiarism. A similar announcement followed concerning advanced level geography (BBC 2006b). The following week, on the 6th October, the Qualifications and Curriculum Authority (QCA) announced a sweeping range of changes to secondary school coursework (QCA 2006f).

All of this was despite the assertion by the Assessment and Qualifications Alliance (AQA) (2007) that coursework, or 'school-based assessment' (p1) as they termed it, more realistically represents how people learn outside of school. They described how 'in the world outside education it is relatively unusual for anyone to sit down and think and write continuously for two hours, as they must in an external examination' (p.2). People learn outside the classroom collaboratively and with help from others. School-based assessment was boosted by the introduction of two-thirds coursework applied GCSEs, including applied science.

The QCA (2006f) decided that coursework that was teacher set and marked in business studies, classical subjects, economics, English literature, geography, history, modern foreign languages, religious studies and social sciences, would be ended and replaced by controlled assessments. Yet, in art & design, design & technology, home economics, music and physical education, internal assessments would continue with stronger safeguards.

The changes were introduced in September 2009, with the exception of mathematics where the change commenced from September 2007. Science was discussed in a BBC article entitled 'GCSE home coursework is scrapped' (BBC 2007). In this, it was stated, that due to the changes made to the new science curriculum, science coursework in all forms of GCSE science would be unaffected. The National Association of Head Teachers (NAHT) warned of the inherent dangers of the examination system (BBC 2006e). They complained about poor marking of examinations and a record number of appeals by pupils and schools to have marks changed: one in four GCSE examinations that were sent for regrading ended up with a changed grade. Remarking cost a lot of money: on average £45 per GCSE paper, according to the NAHT, who questioned if the figure was even higher. The Joint Council for Qualifications (Times 2007c) asked for examiners to set easier questions in science GCSE papers by increasing the number of low demand questions in papers from 55% to 70%.

The importance of science as an academic subject was highlighted by the then prime minister, Tony Blair (BBC 2006d), The National Endowment for Science Technology and the Arts (2006) and the House of Lords select committee (2006), amongst others. Scientific innovation was described as the cornerstone of the British knowledge economy and essential for the future prosperity of the nation. Coburn (1995) wrote how even educated people understood little science. Littledyke (1998) commented on how educators should strive for pupils to develop into 'critically aware adults who can respond flexibly, humanely and intelligently to the demands of an increasingly complex world' (p.ix).

The effectiveness of both coursework and examinations in the assessment system have come under criticism, whilst at the same time, the importance of science education has been recognized. My research intentions have included an investigation of the views of pupils and teachers towards the science coursework that they work with, and how pupils learn through examination and coursework in order to ascertain the effectiveness of coursework in GCSE science.

1.3 The importance of this research – how does it contribute to knowledge?

No formal evaluation of the coursework-based applied science GCSE has yet been undertaken (Gadd 2004) and McNally (2000) pointed out a lack of literature reflecting a teacher perspective on coursework and investigative science. Therefore, there is an existing need for an evaluation. My study has provided this and expanded upon it by analysing a range of GCSE science disciplines including the new science 2006 award by contrasting pupil learning in coursework and exam based study.

The importance of research such as this was discussed by Halsall (1998), who questioned how change in schools, such as the implementation of new science curricula, are imposed on teachers from above. He considered that teachers should contribute to the effectiveness of improvement to balance the targets set by policy makers as evidenced, for example, by indicators in league tables, which provide rather crude indicators of achievement. External organisations were said to proffer expertise and claim to know what is best in the classroom, silencing the voices of teachers (Carter and Halsall 1998). A lack of teacher viewpoints in the literature surrounding science investigations was commented on by McNally (2000). To counteract this reported lack of voice from the teaching profession about educational change, this research has provided views of teachers and children from a case study setting, drawing on complementary data from local schools, on the impact of coursework, as a significant element of teaching and assessment in science education.

I have used the findings from this research as a basis to argue for science courses within the GCSE curriculum, which fit the learning needs of pupils in the school where I was employed. I have been able to use quantitative analysis to show in which areas of the curriculum pupils are achieving more in terms of examination results. Qualitative analysis has enabled me to ascertain the areas that pupils enjoy and feel confident in tackling and where they feel stressed and unsure. I have also analysed the learning behaviour to ascertain any differences between coursework and exam-based learning.

1.4 Structure of the thesis

The thesis continues with chapter two, 'Literature review'. This contains a discussion of the relevant literature encompassing the scope of this research and the latest research in relevant areas. The literature is separated into four sections: Curriculum, Teaching, Learning, and Assessment. Each section underpins the data I have collected in the proceeding chapters and has provided a theoretical backdrop with which to evaluate my data.

Chapter three, 'Research design, methodology and methods' discusses the research methods I have employed, and my epistemological and theoretical perspective. I have explored their relevance, how they will have answered my research questions and analysed possible problems with them.

The next series of chapters explore the qualitative and quantitative data I have collected. Interspersed amongst them are examples of field notes that demonstrate or highlight particular points in, or are relevant to, the data:

Chapter four, 'Pupil questionnaires' discusses the results of a series of questionnaires concerning coursework and exam based science learning given to modular, applied and separate science pupils.

Chapter five, 'Pupil interviews' is concerned with interviewing science students in small groups about their learning.

Chapter six, 'Pupil learning approaches' considers the results of observing how pupils learn in science including the extent to which they learn constructively and how they use assessment for learning.

Chapter seven, 'Teacher interviews' highlights the views of teachers concerning coursework and examination teaching across the specifications including their views of constructive learning.

Chapter eight, 'Quantitative analysis' continues by discussing the results of statistical analyses of coursework and examination results across the applied, modular, separate and science 2006 specifications.

The ideas and discussions I have developed in the preceding chapters are tied together in chapter nine, 'Discussion and conclusions', with field notes providing extra evidence. Suggestions for further research are offered and the strengths and limitations of this research are discussed.

I have included an appendix of research forms and tables, and preceding this is a bibliography.

1.5 Summary

This chapter has outlined the reasons for this research, and the policy background to the coursework debate. It has explained the relevance, originality and importance of the thesis. The next chapter is divided into four sections; Curriculum, Teaching, Learning, and Assessment. Each section offers a review of the relevant research literature that helped me to focus and clarify the research questions that have driven this thesis.

Chapter 2

Literature Review

2.1 Introduction

The aim of this chapter is to draw together strands of relevant literature and to contextualise the study. This provides an overall view of the topics forming the background to my research and has helped me to clarify my research questions. The first section considers the curriculum, including the history of science teaching and learning, and how these have changed to contribute to the science that is taught in schools. I have analysed the three main science specifications discussed in this thesis: modular, applied, and science 2006. The second section, Teaching explores the views of teachers concerning the changing science specifications, and the policies and training they are faced with. In section three, entitled Learning, I have analysed the influence of learning theories and the philosophies of positivism and constructivism on science education. I have investigated how writers in these areas of learning theory believe pupils learn in science, what motivates or de-motivates them, their views about the science they learn, and why some learn more than others. I have investigated literature concerning experienced and perceived differences in coursework and examination achievement by boys and girls. In the final section, Assessment, I have addressed the educational perspectives of assessment, including how the three science specifications are assessed, the role of feedback, and assessment for learning. I have achieved this by researching relevant literature through books, journals and internet sites. The latter particularly belong to AQA and the QCA who tend to publish specifications and reports online.

Part One: The Curriculum

In this first section, I have researched the definition of coursework in GCSE science and how the secondary school science curriculum has developed, to include changes in how and what pupils learn, and the introduction of coursework assessments. I have reviewed what modular, applied and science 2006 consist of, in terms of coursework, and I have discussed the policy issues that affect the development, and choice of curriculum.

2.2.1 What is a coursework investigation?

Coursework has been a part of the curriculum since the inception of the GCSE (Jenkins 2004). However, finding an agreed definition of what constitutes coursework has proved difficult according to Elwood (1999). The Qualifications and Curriculum Authority (QCA) (2006e p.6) defined coursework as being either:

- Written work and extended essays
- Project work and investigations (the latter especially in science)
- Practical experiments (also in science)
- Production of artefacts
- Production of individual or group performance work
- Oral work
- Statistical and numerical tests

The QCA (2007 p.4) decided that in order to be effective, coursework should:

- Accurately assess what it is trying to assess
- Test skills and attributes that cannot be tested in a terminal examination
- Be embodied within the course to reduce the overall burden on teachers and students
- Be robust, by including examples of work produced in lesson time
- Be consistent, ensuring that similar subjects have similar coursework

Such tasks, are usually set by the teacher, taught in non-controlled conditions (i.e. not in exam conditions) and marked by the teacher, but sometimes verified by external examiners appointed by exam boards (QCA 2007). The tasks form a part of the overall marks for GCSE science examinations. The science 2006 coursework is an example of how the QCA (2007) recommends coursework in most GCSE subjects to be taught, as it will be taught in controlled conditions with pupils working in silence, thus juxtaposing some of the ideas of coursework and testing by examination. As QCA (2007) pointed out, 'its newer incarnation is closer to structured assignments developed by awarding bodies' (p.9).

The QCA(2007) also noted how coursework can allow pupils to be assessed in ways not possible by examination such as designing scientific investigations, known as 'the skills of the trade' (p.10) and using the tools of the trades – scientific apparatus.

The Assessment of Performance Unit (APU) was instigated by the then Department of Education and Science (DES) in response to concerns about educational standards in the 1970s. The APU designed the first significant assessments based on pupils conducting experiments (Orpwood 2001). The APU defined an investigation as 'a task for which the pupil cannot immediately see an answer or recall a routine method for finding it' (Gott and Duggan 1995 p.42). This often involves pupils conducting an experiment, and is distinct from other classroom activities such as answering questions in books. The APU in table 2.1 defined a series of questions that may be used in investigations, the examples they display all involve practical, experimental science.

Table 2.1 APU investigation questions

Problem type	Example
Decide which...	...kind of paper towel which holds most water
Find the effect of...	...the water level in a container on the rate at which water runs out of a hole in the bottom
Find a way to...	...adapt weighing scales that won't measure up to the baggage allowance
Find the cause of...	...the failure of a light bulb to light a circuit
Make a structure/machine to...	...support a brick using one newspaper and sellotape

(Gott and Duggan 1995 p.42)

Watson, Goldsworthy and Wood-Robinson (1999) categorised science investigations into six types:

- Classifying and identifying – patterns in chemicals or identifying species
- Fair testing – exploring relationships between variables
- Pattern seeking – observing events as they occur, e.g. ecology
- Investigating models – how do theories work in reality?
- Exploring – investigating an event over time e.g. the development of frogspawn
- Making things or developing systems – pupils make things to meet a need

Science investigations are one particular type of problem solving. This can includes the undertaking of experiments to collect empirical results (Duggan and Gott 1995). An experiment, wrote Medawar (1982), should 'nourish the senses' and 'enrich the repertoire of factual information' (p.94).

A classification table for school investigations was discussed by Woolnough (1994). Table 2.2 classifies work in order of how much of an investigation is left for the pupil to decide, or decided by the teacher. Each 'X' represents choice given to the student. For example, Type 1 investigations are where students choose the problem, theory and the solution. This shows that coursework investigations can be classified in terms of who decides what about it. Tytler (1992) considered that pupils learn best where they interested in knowledge, particularly when generated by something of personal interest to them.

Table 2.2 Woolnough's classification of school investigations

	Problem	Procedure	Solution
Type 1	X	X	X
Type 2	X	X	
Type 3	X		
Type 4			

Woolnough (1994 p.32)

To summarise, an investigation is a piece of work, normally involving practical science, designed so that pupils can answer a scientific problem. Coursework was described by Jenkins (2004) as 'work undertaken by pupils, ostensibly as an integral part of the teaching and learning process, and commonly assessed by teachers' (p.36). I have added to this definition to take into account the different kinds of coursework now used to assess skills as a part of science GCSE: a specific type of investigation, designed to assess skills that are not assessed by examinations, such as practical work and the collection and processing of data. It can be an experiment, completed by a group of pupils who write up and process their results individually, over a series of lessons, which are then marked by their teacher, such as those found in applied and modular / separate science. It can also consist of a set of results from an experiment, again collected collaboratively, which are used to individually answer a test paper under exam conditions, which is marked externally, as in science 2006.

2.2.2 The arguments for and against coursework

The QCA (2006c) review of General Certificate of Education (GCE) and GCSE coursework arrangements provides an overview of the pedagogic reasoning for and against coursework and exam based study:

For:

Coursework encourages effective pedagogic practices that precipitate formative assessment of learning.
Coursework encourages teacher participation in formative assessment.
It assesses things that examinations cannot, such as laboratory work with scientific equipment, thus increasing the variety of assessment.
It motivates students and encourages independent and active learning.

Against:

It can prove difficult to authenticate coursework as a student's own.
Judgements on pupil performance, such as conducting an experiment, can be hard to make.
Coursework can be difficult to standardise across centres.
Some pupils find coursework time consuming and de-motivating.

In summary, coursework can encourage formative assessment and motivate students, but could lead to accusations of plagiarism (which I have discussed in more detail in section 2.4.8 Collusion and coursework) and de-motivate pupils.

2.2.3 The historical framework: teaching, learning and coursework

Science has been an essential part of primary and secondary education since the advent of the National Curriculum in 1991 (Donnelly 2000). Sc1 has been one of four statutory attainment targets within science for all children from 5 – 16 years old. It is within Sc1 that coursework is assessed. Sc2 is biology, Sc3 chemistry and Sc4 physics. These are assessed by examination. It is also an international concept, reflected, for example in the educational policies of the USA where it forms one of the national science education standards, and in Canada where scientific enquiry is a foundation statement for scientific literacy (Toplis and Cleaves 2006).

Well before the advent of the National Curriculum and Sc1 investigations, coursework in the form of written up practical assignments were a part of science education. By the turn of the century it had become such an integrated part of the science curriculum that the Centre for Science and Technology (2000) discovered in a 1999 survey of 1430 teachers and 925 head teachers, that science teachers felt more confident in teaching this than any other component of science GCSE.

The origin of practical work in science has its roots in 1851 when state support grants were made available to schools, and in 1854 when the Department of Science and Art was set up. As a consequence, school laboratories were stocked with equipment but the emphasis was very much on demonstrative work by the teacher (Gott and Duggan 1995). Later that century influential textbooks such as *A Course of Elementary Instruction in Practical Biology* by T H Huxley had been published. Such works provided an outline of scientific thinking in their respective disciplines and encouraged practical laboratory-based investigation (Slingsby 2006). Jenkins (2007) wrote of how the British Association for the Advancement of Science (BAAS) in 1867 reported that teaching science should allow for the collection of facts and observations, alongside inductive and deductive reasoning. This was in response to objections, at the time, from people who thought that science was only about learning facts.

The beginning of coursework-based science lay in the work of Henry Armstrong who at the turn of the last century developed the ideas of earlier educationalists such as Huxley and Spencer and advocated a heuristic approach. This, by definition encouraged investigation within a subject that had hither to been taught through demonstration and books (Jenkins 2007). Armstrong believed that 'experience should precede theory, precept should precede concept' (Matthews 1994 p.20). This coupled with the rise in the social and economic importance of science led to 'a move towards encouraging practical work in schools, in the way that we now take for granted' (Gott and Duggan 1995 p.17). There were criticisms later on that the approach restricted the science taught due to a lack of laboratory equipment, contrasting the origin of practical work in schools. Jenkins (2001) described how the eminent science educator and writer FW Westaway labelled heurism as 'an approach to science teaching in which practice would not yield with precept' (p.92).

Armstrong's ideas began to fall out of favour at the start of the last century, and an approach emphasising content over method ensued (Gott and Duggan 1995). Most practical work up until the late 1950s consisted of a recipe to illustrate theoretical concepts. Jenkins (2001) described how in this period, science teaching placed an emphasis on pupils learning to recall factual information, and solve routine numerical problems using set calculations. In the 1950s the Science Masters Association (SMA)[1] considered the state of science education in the then secondary modern and grammar schools. Their reports in 1953 and 1957 suggested a more child-centred approach where pupils could carry out investigations as part of their practical work. During this period very few pupils were given a 'broad and balanced science education' (Jenkins 2004 p.33), with far more boys than girls studying any form of science and the physical sciences being under-represented amongst boys and vice versa with the biological sciences. In this era selective grammar schools and public schools existed, although most pupils studied in secondary modern schools.

The Kerr report into the nature and purpose of school science practical work in 1959 found that pupils lacked investigative finding out skills as well as not having a scientific way of thinking and behaving, which according to Gott and Duggan (1995) meant that they did not follow a scientific method or analyse data scientifically. However, Bruner (1960) indicated that children learned effectively through the physical manipulation of objects and Schwabb (1962) believed that investigative and practical science supported how children learned. This led, according to Mintzes, Wandersee and Novak (2004), to an increased emphasis on pupils learning through practical skills such as measuring and interpreting data, rather than learning facts. During this period, science assessment concentrated on the recall of scientific knowledge, with pupils answering essay or short answer examination questions (Orpwood 2001).

In 1965 the Certificate in Secondary Education (CSE) was introduced. It aimed to provide a more work related and less academic route through school than the more academic

[1] The Science Masters Association was a voluntary body with an interest in science. Over time it amalgamated with other such bodies such as the Association of Public School Science Masters, later known as the Science Masters' Association, the Association of Women Science Teachers, the Science Association and the Association of Science Teachers to become the Association for Science Education (A.S.E.)

G.C.E. O levels. It was available in three modes, the third of which 'allowed teachers to examine their own pupils and award appropriate grades' (Jenkins 2004 p.35). The CSE had an increased emphasis on coursework, which took the place of laboratory practical work, fieldwork and projects. Teachers commonly assessed this as part of a pupil's grade. Pupils learned through doing practical science as well as the factual recall emphasised in previous years.

The Nuffield science projects of the 1960s were a consequence the SMA reports. As a consequence, Nuffield Science was designed for pupils to discover science and use the scientific method to develop their scientific thinking (Gott and Duggan 1995). It included ideas for practical work that have been in use ever since. Jenkins (2007) wrote that 'students were encouraged to think in the way practising scientists think' (p.270). A project formed part of the A level overall assessment. Criticism came from Matthews (1994) who complained of Nuffield Science being responsible for disquiet about scientific achievement and participation. Woolnough and Allsop (1985) commented on Nuffield Science as having 'spawned contrivances designed to produce the "right" answer every time' (p.30). Hodson (1990) considered experiments and investigations as a way of convincingly revealing a meaning, and not to investigating the negotiation and contradiction of meaning. So, although practical investigations were becoming more common in the curriculum, doubts as to their contribution to the development of pupil investigative skills remained. Driver (1983) wrote of students gaining an increased understanding of scientific ideas through experiments but added that 'this approach will not succeed if the complementary role of imagination is not also recognised' (p.49). The era of Nuffield, the 1960s and 70s were tagged 'the Brave New World of science education' by Slingsby (2006 p.283). He described how the emphasis was changing from separate subject specialisations to a one size fits all science to be taught by all science teachers.

By 1969 a scheme in the USA attempted to address what scientists actually do at work and relate it to teaching. It was named Science - A Process Approach and spawned the 'process and skills' movement, which valued process above scientific concepts. Process and skills schemes such as Warwick Science were introduced in the UK, partly as a reaction to teachers prioritising concepts and knowledge over processes, which was not entirely unconnected to Nuffield Science. Gott and Duggan (1995) wrote of the problems with the process approach; it was difficult to incorporate into a scheme of work, as schemes can lack continuity as they concentrate on the process and jump between parts of the content leaving pupils to have to put together the pieces together. Mintzes, Wandersee and Novak (2004), described how children participated in a 'meaningless succession of hands on activities devoid of understanding' (p.37) where they were not taught to relate their practical work to scientific concepts. Therefore their learning lost meaning and relevance.

The Department of Education and Science (DES) set up the Assessment of Performance Unit (APU) in 1975. Its purpose was to survey school populations to identify national capability levels.The APU designed the first significant assessments to be based on pupils conducting experiments (Orpwood 2001).

In the 1980s, research began to show that children did not enter their science classes as passive learners. Instead, it was realised that students held concepts and ideas that may be in contrast to those they are being taught (Duit and Treagust 2003). The Secondary Science Curriculum Review in 1981 promoted a constructivist perspective on science learning, and influenced Government policy on school science in the following years (Jenkins 2004).

In 1984 the Government announced plans to drop the GCE and CSE system in favour of one examination for all. This led to the introduction GCSE qualifications in 1986 and the first examinations in 1988. Jenkins (2004) pointed out that for the GCSE, GCE and CSE were combined as 'an amalgamation of different curriculum histories and methodologies' (p.39), meaning the juxtaposition of the more academic, factual recall based GCE, and the vocational, coursework leaning CSE. Within GCSE, double science courses, the direct predecessors of applied science and science 2006, were introduced. Jenkins (2004) commented that 'between 1989 and 1996 for example, the 197,000 entries in GCSE physics had fallen to 18,000 while, during the same period, [double]science entries rose from 142,000 to almost half a million' (p.39). As Medawar (1982) pointed out, 'isolation is over' (p.30). He was considering the cross fertilisation of ideas between physics, biology and chemistry, which seems to have been mirrored here as the GCSE sciences merged. Woolnough (1994) pointed out how:

> In the late 1980s only a minority (10 per cent) of students studied all three sciences up to the age of 16, in approximately 30 per cent of the curriculum time. Now all

students are studying a balanced science course the majority in approximately 20 per cent of curriculum time (p.23).

The GCSE marked a change in approach to assessment, with an emphasis on coursework, oral examinations, portfolios and investigations. This replaced the GCE reliance on the recall of factual knowledge and procedural knowledge (Elwood 1999). Coursework was welcomed as a motivator of pupils that has improved GCSE performances (Elwood 1999). Another major development affecting education was the Education Reform Act of 1988 (Policy Studies Institute 2007). National testing at the ages of 7, 11, 14 and 16 (Key Stages one, two, three and four) was introduced, accompanied by the introduction of the National Curriculum (NC), which for the first time specified programmes of study and attainment objectives for all pupils attending maintained schools. This led to an increased continuity between schools across the country and across key stages in terms of what was being taught. The impetus for the NC arose from concerns from the Government about teaching methods, particularly the progressive methods of the 1970s (Moore 2005), who argued that a lack of accountability and a lack of agreed objectives in schools pointed to the need for a curriculum that every pupil must study. Jenkins (2004) described it as based on the notions of 'breadth and balance' (p.39) across a range of secondary school subjects. However, Davies, McCarthy, Shaw and Sidani-Tabaa (1993) wrote of a positivist slant to assessment in the NC. With the NC came school performance tables and regular national tests that Black (2001) has criticised for not improving pupil performance or understanding. Bell and Donnelly (2006) commented on how the NC removed technical and vocational elements of the curriculum, leaving 'a framework of subjects that is at least 100 years old' (p.1394). The vocational element returned in the form of the General National Vocational Qualification, in 1990, and more recently with the introduction of applied science.

The NC changed *how* science was now taught, with a constructivist approach now prevalent across the science curriculum (Watts and Bentley 1991), which is consistent with the work of Vygotsky and Bruner who recognized the social nature of learning. Rather than what Driver, in Steffe and Gale (1995) described as a 'list to be taught' (p.399) the curriculum was to take into account, and build upon the concepts and constructs that children brought into the classroom. All science learners were now assessed through coursework, and objective (multiple choice) tests, as well as written examinations. There was more emphasis on learning scientific processes than the factual recall of positivist knowledge.

The NC developed as a knowledge-based not learner-based model to counter a previous learner-centred collectivist ideology prevalent in post war education (Littledyke 1998). Planning and assessment of learning was put before the process of learning, and schools were made more accountable for the results they produced with the implementation of league tables, leading to competition between establishments. The increased subject content of the NC has led to less teacher autonomy and individualism in planning as they strived to cover the content. This was particularly acute with the pre-applied / science 2006 coursework being reduced to a few attainable topics (Osborne 2004).

Coursework was boosted by the implementation of scientific investigation (Sc1), which was one of the four science attainment targets introduced when the NC was revised in 1991. Sc1 is the practical skills-based target, usually assessable by coursework, completed and marked in a school, with a sample moderated by an external examiner. Assessed coursework was now a real prospect for every GCSE science pupil and teacher. Jenkins (2004) noted how initially teachers faced difficulties in understanding and teaching Sc1. However, Parkinson (1994) described scientific investigation as being 'mentally taxing, requiring the pupil to plan his/her experiment, encouraging pupils to question their own understanding of scientific phenomena, encouraging pupils to search out information for themselves' (pp.106-7). Orpwood (2001) described how the inception of coursework led to difficulties as the public, and universities, 'thought they knew what traditional tests measured, and new, unproven forms of assessment lacked the familiarity and thus the credibility of the traditional ones' (p.143).

Osborne (2004) reviewed Sc1, writing of how teachers and pupils are disengaged from the assessment procedure. Gott and Roberts (2004) also wrote about Sc1. They found that assessment was difficult and 'takes up an inordinate amount of classroom time' (p.108). Sc1 investigations were used simply to boost pupil grades, as pupils follow formulaic recipe like investigations rather than to teach a range of scientific skills and methods. Gott and Roberts (2004) recommended removing Sc1 coursework totally and instead allowing teachers to decide the practical work done in class as an alternative to coursework assessment. This view contradicts the pro-coursework thinking that underpinned the development of qualifications such as GCSE applied science (up to 2006 at least). Earlier research by Donnelly (2000) corroborated Gott and Roberts' (2004) findings; ten percent of teachers questioned about coursework were enthusiastic, citing an increased emphasis on independent work by pupils. Donnelly (2000) found that the remaining 90% were hostile to Sc1 complaining that it is merely contrived to boost grades, thus agreeing with Osborne (2004) and Monk (2006).

To sum up, over the past 50 years, science education has shifted its emphasis from breadth and memorization, to depth and understanding (Mintzes, Wandersee and Novak 2004). Thus the emphasis on children's learning has changed from rote learning, discussed by Mintzes et al. (2004) when students 'accumulate isolated propositions' (p.39), which fosters a poor retention of new ideas, and the inability to apply new knowledge. Instead, there is now more emphasis on meaningful learning. This is where the learning is incorporated into the learners' framework of knowledge by building on their previous knowledge, it is learning that the learner wants to incorporate, and it has meaning to them. (Mintzes et al. 2004) This constructivist change has been accompanied by an increased role for coursework through Sc1, which is now embedded in the GCSE science curriculum.

2.2.4 Modular and separate science GCSE

The science that most pupils took before the development of applied and 2006 science was a double GCSE course consisting of examinations and coursework. The AQA modular interpretation of the award contained six modular multiple-choice examinations spread over the first year of GCSE (AQA 2004b). This was worth thirty percent of the qualification. Two short answer examinations taken at the end of the course counted for fifty percent. The final twenty percent was made up of two or three pieces of coursework (Sc.1). The scientific content was taught through twelve modules, with four of them devoted to each scientific discipline. Millar and Osborne (2000) argued that the content of double GCSE science was akin to a diluted form of the 1960s GCE curriculum: a series of value and opinion free 'facts'. This outlines the positivist viewpoint they claim underpinned the subject. They added how mental recall was the most important factor in answering science examinations. This goes against the constructivist outlook on science education prompted by the Secondary Science Curriculum Review in 1981 (Jenkins 2004).

The coursework component (Osborne 2000, Gott and Roberts 2004) was assessed over four skill areas of planning, obtaining, analysing and evaluating. Pupils were allowed to complete four pieces of coursework with the best mark for each of the four components from any of the pieces being submitted. Another stipulation is that two of the sciences must be represented in the work. Gott and Roberts (2006), reported problems with assessing the coursework. By relying on pupil reports of their investigations, there was little opportunity to observe, and assess, pupils at work, and this would not be possible with large classes. Because of the time needed to complete, and write up investigations, it proved impractical to do very many of them, and pupil performance, according to Gott and Roberts (2006) is influenced by the choice of task, as well as the complexity. Therefore, if pupils were not interested in the few coursework topics chosen, their assessment could suffer. Osborne (2004) commented on the ubiquitous nature of certain modular coursework investigations as the 'overwhelming dominance of three investigations –measuring the resistance of a wire, the rates of a chemical reaction and the rate of osmosis in a potato' (p. 13). Using a small number of tasks led to them becoming routinised, according to Gott and Roberts (2006) with a small number of repeated tasks – a test repeated three times, a graph produced a table of results drawn up.

A perceived aim of the qualification according to AQA (2004b) was to 'acquire a systematic body of scientific knowledge, and the skills needed to apply this in new and changing situations in a range of domestic, industrial and environmental contexts' (p.13). So, before the advent of applied science, scientific applications were being stressed as part of science GCSE. Also included was Ideas and Evidence in Science, to be taught through the twelve modules. This included the teaching of issues, such as how the public get scientific ideas through the media, how scientific discoveries are reported and how scientists are sometimes unwilling to give up ideas that have served them well in the past (AQA 2004b). Such ideas, particularly science and the media, have been carried forward by science 2006.

McAteer (1998) researched and compared Popperian scientific theory with pre 2006 / applied GCSE science and more specifically to statements concerning GCSE coursework. Her first point was that Popper took an observational approach to getting acquainted with a problem, whereas GCSE science was more of a case of getting answers that fit with a pre taught theory. Therefore, Popper's ideas, which focus on the provisional nature of knowledge, are in opposition to how coursework is presented, where knowledge is proposed as uncontested truth. McAteer's (1998) second point stated that teachers chose relatively problem free investigations so that the correct answers could be sought. As

Harlen (2004) agreed that 'when high stakes judgements are associated with teachers' assessment, one effect is for teachers to reduce assessment tasks to routine events and restrict students' opportunities for learning from them' (p.67). The AQA modular science 2006 specification asks pupils to 'consider critically the reliability of the evidence and whether it is sufficient to support the conclusion, accounting for any anomalies' (AQA 2004b p.144).

McAteer (1998) wrote how the GCSE approach:

> ...gives little scope for interaction between the knower and the known, and gives the student no opportunity to build up knowledge by a process of open-ended investigation. The complete form of knowledge required is pre-specified, and thus the student has no opportunity to acquire knowledge through a series of tentative and incomplete understandings of the phenomena experienced, (p.5).

This pre-specified knowledge of facts goes against Kuhn's notion that 'scientific fact and theory are not categorically separable' (Kuhn 1996 p.7). There is no notion of originality in scientific thinking. But is this possible at GCSE level?

Although the exam board supplying the syllabus nor the type of GCSE science were referred to, it can be assumed (but not proven) that the science mentioned was GCSE double award science, as most pupils in 1998 studied this, rather than single award or separate sciences.

Kuhn (1996 p.25) listed the foci he felt were normally used for scientific investigations:

1) The paradigm must be particularly revealing of the nature of things
2) The facts compare with the prediction from the paradigm theory
3) Empirical work articulates the paradigm.

Taking these foci into the realm of GCSE investigations these foci would look like:

1) Does the investigation fit with an accessible piece of scientific theory?
2) Can pupils produce a prediction from the scientific theory they know?
3) Will experimental work support their prediction and scientific theory?

This concurs with McAteer's (1998) views about pre-specified knowledge in scientific investigations where the scientific theory leads the research / coursework and results are driven to prove it. For example, the topic Resistance of a Wire was a commonly used piece of coursework for modular GCSE science and for applied science. In it pupils measure the current and voltage of different lengths, types or thicknesses of wire to calculate resistance on ohms. It is well used because it can give accurate (and sometimes inaccurate) results that fit the prediction and scientific theory well, as McAteer (1998) pointed out. Therefore, pupils can gain high marks. Allen (2007) noted that where pupils have bias towards a certain conclusion it improves their engagement with the subject.

Resistance could be described as deductive in that pupils are taught the 'facts'; the logical principles, according to the science curriculum, and then obtain results and assess evidence to concur with these logical principles. But supplying empirical results alone that fit a theory take the 'mystery' out of science, as Hadzigeorgiou (1999) points out; 'scientific enquiry as well as assertive rational judgement that is entirely based on empirical evidence is nonexistent' (p.45).

Pupils in Toplis's (2004) study commented on the need for inaccurate anomalous results via investigations such as resistance of a wire, to get more marks. The modular science mark scheme gave marks for anomalous results and improvements to the method. Medawar (1982 p.89) pointed out when talking of research science investigations, 'too much is made of validation...a realistic methodology must be one that allows for repair'. Resistance would appear to be a critical or Galilean experiment according to Medawar (1982): an action or procedure that is designed to test a preconceived opinion by examining the logical consequences of holding it. It is an experiment to discriminate between the possibilities of resistance increasing or of it decreasing as a piece of wire is lengthened.

So what sort of hypothesis or prediction should pupils write? They could 'make an informed guess which might explain the phenomena under investigation', as Medawar stated (1982 p.101). In fact, AQA (2004b p.141) stated that pupils should 'use detailed scientific knowledge and understanding to plan...and to justify a prediction where one has been made'. So, rather than an informed guess, an idea backed up with science should be used.

Use of equipment in science investigations has been criticised by pupils (Toplis (2004, Toplis and Cleaves 2006). Pupils in their papers complained of inaccurate or not working apparatus. Resistance in my experience is an investigation prone to faulty equipment. If voltmeters or ammeters and batteries are inaccurate or faulty, pupils have to share results from those who have a working experiment. They can, however, obtain erroneous results and gain good evaluation marks as mentioned above.

How does such a piece of coursework stand up against the criticisms Medawar (1982) made about scientific methodology? He analysed the validation, amongst other things, of scientific investigation. Validation he took to mean as the grounds upon which statements are judged true or false; i.e. this result proves this is true. Scientists, he believes, are 'oppressed by the fear of error' (p.82). However pupils, at least those doing modular science investigations, needed results with errors in to get good evaluation marks, as Toplis and Cleaves (2006) discovered in their interviews, and Monk (2006) concurred.

In 2006, Toplis and Cleaves considered how an investigation should form part of a scheme of work rather than a standalone investigation and commented that 'when investigative work in schools is fitted into a number of lessons as summative assessment, well before the GCSE course is finished, difficult management issues arise and result in considerable stress for all involved' (p. 81).

Although modular, and other pre-science 2006 double award specifications, were withdrawn, the layout of the specification remained in single science qualifications until the summer of 2007, where it was replaced by science 2006 coursework. Separate qualifications in biology, physics and chemistry have become more popular for able students since the mid 2000s. Slingsby (2006) bemoaned how combining the sciences has not worked, as teachers have not been trained in different disciplines and philosophies and concludes that it is better to teach pupils the existing scientific pillars of biology, chemistry and physics. Resources could be directed into researching the nature of scientific thought in these disciplines.

2.2.5 Applied science

'Reform of the science curriculum is a topic of apparently perennial concern. It is motivated in part by pressure to reverse the perceived declining interest in the study of science (Bell and Donnelly 2006).

The creation of vocational courses, such as applied science were part of government policy to orientate school work towards future employment possibilities, which in turn may reduce a skills shortage in the workplace, and motivate pupils (Bell and Donnelly 2006). The original vocational qualification, introduced in 1990 was the general national vocational qualification (GNVQ). In 2002 the GNVQ started to be phased out, due to its low status and a perceived separation from the academic curriculum (Bell and Donnelly 2006).

In place of GNVQ, eight new GCSE qualifications were introduced to provide a more vocational path to the workplace and provide an alternative to the traditional GCSE qualifications. This was a consequence of what the House of Commons select committee for Science & Technology (2002) described as 'an attempt by the Government to raise the status and take-up of vocational qualifications by aligning them more closely with traditional courses' (p.18). The final GNVQ qualifications – the original vocational GCSE alternatives were awarded in 2007.

The applied GCSEs were initiated in applied art and design, applied business, engineering, health and social care, applied information & computing technology, leisure and tourism, manufacturing and applied science. All were double award GCSE qualifications. The qualifications were launched without being trialled in schools beforehand and without extensive materials to support them (Bell and Donnelly 2006). The term 'applied' was used where existing GCSEs shared the same name, and replaced 'vocational' which may have had a negative connotation relating to 'second best in the eyes of many' (Gadd 2004 p.72).

Based on these qualifications, the government, through the teachernet website (2006), outlined some ambitious aims for school-based vocational learning:

> The Government is committed to creating and maintaining a robust and respected world-class system of vocational and technical education to match the country's academic tradition. GCSEs in vocational subjects play an important role in achieving this objective. They were introduced in September 2002 to provide young people with the opportunity to explore vocational learning in a distinctive and innovative way.

The QCA applied science website (QCA 2006a) described the qualification thus:

- to provide an introduction to a broad vocational area
- to enable progression to further education, training or employment
- to be available at key stage 4 and post-16

An insight into the thinking behind applied science comes from Nicholson and Holman (2003). They wrote that 'the attempt to combine work in all three sciences into a two-GCSE slot has led to a severe overloading of content, particularly at key stage 4' (p.25). They add that GCSE papers place heavy emphasis on the recall of factual knowledge or its 'application in standard situations' (p.26). By this, I assume they meant in purely scientific not vocational or work related situations. The applied syllabus contained less content, particularly in physics. The course has met the 2006 statuary requirements for science but not the full Programme of Study. Bell and Donnelly (2006) noted 'a considerable reduction in the substantive science knowledge required to be taught compared with that in established science courses in schools' (p.139). Therefore, according to Ponchaud, it has been regarded as 'not the most appropriate for those who are attempting to take academic advanced levels in science subjects' (2005 p.14). Applied science was seen to target low achievers, and disaffected pupils, and how teachers were concerned that by choosing applied science, pupils were narrowing their future options away from scientific A levels (Bell and Donnelly 2006).

Long before this debate Medawar (1982) pre-empted Gadd's (2004) assertion that the term 'vocational' has a negative connotation when related to GCSE science by writing that 'a class distinction has grown up around the difference between 'pure' and 'applied' science' (p.14). He went on to state that 'the highest form of science must be that which is spontaneously offered by the creative imagination, not something wrung from us by the presence of necessity' (p.14). He was discussing research science at the highest level but this outlines how different labels have affected how some people view aspects of science.

The applied science specification was designed to 'set learning in vocational contexts and develop understanding of commerce and industry' (Pouchaud 2005 p.13). There has been an aspiration for schools to develop links with workplaces, but the difficulties in getting large numbers of pupils to workplaces, which often have conflicting demands on their time, have been pointed out by Bell and Donnelly (2006).

The design of the applied science specification was influenced by the previous GNVQ award, particularly by having portfolios of coursework and specific tasks for pupils to do (Bell and Donnelly 2006). The original Applied Science curriculum consisted of three units:

Unit 1 - Developing Scientific Skills: 7 pieces of coursework
Unit 2 - Science for the needs of Society: 1 hour short answer examination. This could be taken in January & June. Higher and foundation tiers are available. A maximum grade of C is available with the foundation tier.
Unit 3 – Science at Work: 4 pieces of coursework

Each unit was worth one third of the final grade. Unit 2 was assessed by a written examination consisting of short answer questions. Units 1 and 3 were assessed purely by coursework. Many schools have used applied science to target C/D grade borderline pupils in place of a single GCSE is science (Pouchaud 2005). He argued that that 'GCSE results for the first year (2004) [of applied science] showed that a much higher proportion of students gained higher grades than in single award science (26% compared with 9%), (p.14).

The specification was revamped for examination in 2008 with four units now in existence. Unit 3 was split into separate units called Developing Scientific Skills, and Using Scientific Skills for the Benefit of Society. Along with this, the total number of pieces of coursework to be submitted fell. For unit 1 two pieces were to be submitted alongside a mark submitted by the teacher for research and communication skills. Unit 3 now consisted of three pieces with an additional mark for vocational application, and unit 4 became four pieces. So, nine rather than 11 pieces of coursework were now needed. Unit 2 remained a one hour tiered short answer examination.

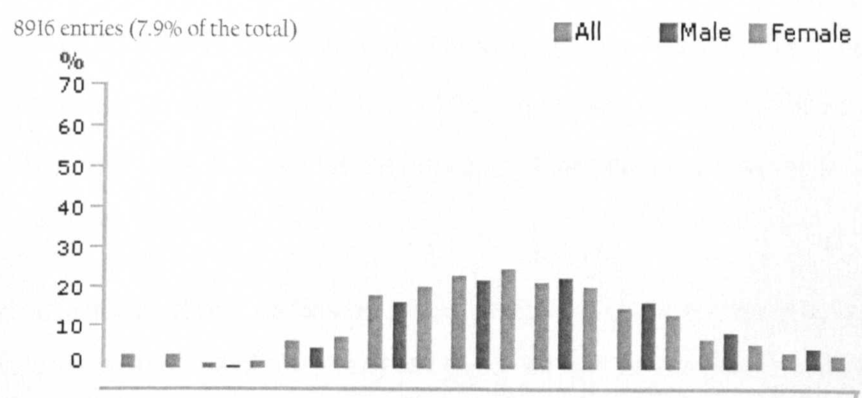
Additional applied science could be taken alongside core science 2006. As with the revamped 2008 specification, it was split into four sections. Units one and two were the same as for the full specification but for unit 3 each candidate had to complete only one investigation. This could be food, forensic or sports science and must have a vocational angle to it. Unit four was omitted, leaving three pieces of coursework to be submitted.

Some pupils found completing many pieces of coursework difficult. Pouchaud (2005) described how 'inevitably some find it difficult to complete and organise their coursework' (p.15). Yet, for others a coursework approach has proved beneficial, particularly those who do not perform well in written examinations. However, a benefit of the course is that students realise that coursework based learning is down to them and they tend to get on with writing and improving their work (Pouchaud 2005).

The first cohort of applied science pupils, in 2004 (figure 2.1) achieved lower grades than their double award colleagues. Double award science ran for over ten years and teachers used established methodological pathways to maximise learning in the examined and coursework parts of the syllabus. Applied science has not been worked out to such a degree during the time period of this research and it will take time for teachers to settle on assignments that produce the highest grades and use available resources.

Figure 2.1 National applied science results 2004:

Source – BBC Education website (2006a)



	A*A*	AA	BB	CC	DD	EE	FF	GG	U
All	0.1	1.2	6.8	18.9	23.9	21.8	15.1	7.8	4.4
Male	0.0	0.7	5.3	16.7	22.7	23.2	16.8	9.3	5.3
Female	0.2	1.7	8.1	20.9	25.0	20.5	13.7	6.4	3.5

The results in table 2.1 show that most pupils achieved grades between C-E (57.9%) with D being the grade most achieved at 23.9%.

In spite of the initial results, it seemed clear that applied science was a permanent addition to the curriculum and would be pushed by the government as the way forward for vocational learning in science, possibly until announcements in 2006 about ending coursework began to surface. In the white paper 'Five-year strategy for children and learners' published in July 2004 the Department for Education and Skills (DfES) claimed that quality vocational and applied courses were essential to eradicating drift, disenchantment and dropping out of school by pupils. Their aim was by 2008 to have over 180,000 14-16 year-olds studying vocational subjects (DfES 2006a p.65). Results were initially encouraging. According to the BBC (2006c) there were 18,184 entrants to applied science in 2005, which was twice the previous figure.

The exam board AQA specification entitled Applied Science Double Award 2007 (AQA 2005b) outlined a series of aims that pupils should develop from studying the qualification (p.10):

- The ability to apply knowledge and skills to solving scientific problems in a range of vocational contexts
- The experimental and laboratory techniques used by scientists in a range of vocational contexts, taking appropriate consideration of health and safety issues
- The skills to use scientific instruments and equipment in a confident fashion and with confidence
- An interest in science through studying science in a vocational context
- An understanding of science and how it is used to the benefit of society
- An awareness of how institutions and companies use science in a wide range of essential functions

The vocational approach has included using risk assessments in investigations to give pupils an awareness of how they are used outside of schools. Good precautions have been used in science labs to avoid risks (Allen 1998). Now some pupils were becoming more involved in determining them. Learning in applied science should have an increased focus on group work. Pupils should work in small groups to plan and work on coursework tasks while the teacher monitors and works with small groups. There should be less didactive teaching and more small-group intervention. There will always be an emphasis on the secretarial skills – the mechanics of writing pieces of coursework. AQA (2004a) countered this by claiming that their applied science specification was designed to assess pupils on what they can do as well as what they know. Indeed, part of the assessment criteria for Unit 1 assignments has involved teacher assessment of how well a pupil has completed a piece of practical work by following instructions and working safely. The revamped 2008 (AQA 2006) specifications included marks given for research and communication.

The AQA Applied Science Specification 2006 (AQA 2004a) outlined that 'in order to understand the nature of science candidates must actively experience the scientific environment' (p.10). This goes against Woolnough & Allsop's (1985) statement that 'the development of skills with vocationally directed [scientific] equipment is best left until the student leaves school and is 'on the job" (pp.50-51). Perhaps a lack of suitable equipment or the financial means to buy it and the expertise to use it leads to the realisation that 'schools cannot reproduce what goes on in industry and we cannot pretend otherwise' (Gadd 2004 p.74). Therefore, there may be limits at least to the industrial relevance that can be built into the subject. The Folens textbook (Bell, Brodie, Dawson and Tiernan 2003) contains numerous examples of such emphasis, including butchers, firemen and gardeners applying science. This may encourage pupils to think at an instrumental level, where science is used, but the fundamental ideas behind it are not fully explained (Gott and Duggan 1999). Another point about industrial relevance is that science teachers often lack the resources or the cooperation from scientific companies to send pupils on visits (QCA 2006e, Bell and Donnelly 2006). I have used DVD promotions from companies using science to give a taste of the scientific working environment without having to source equipment or organise problematic visits.

Can this approach help pupils learn and stay motivated in science? Capel, Leask and Turner (1995) described four elements that influence learning:

1) The social context – the relationship between the teaching/learning environment in the classroom and outside – the local area, the National Curriculum etc...
2) Knowledge base – of pupils and teacher
3) Curriculum – the nature and the context in which teachers operate
4) Psychological theories of learning and how a teacher adapts and uses them in the classroom

Introducing applied science could certainly affect all of these elements: changing the curriculum, introducing new more active learning, changing the knowledge base of the teacher to new ideas and slants on teaching topics, and the context of applied GCSEs in the curriculum. I have discussed many factors influencing learning in section 2.4.6 and there are as many factors as there are learners in any classroom, thus pointing out the challenges faced in promoting a concept of learning for all.

In terms of to whom adding applied science to the curriculum would be suitable, the courses were said to be of more value to more able learners who could cope with the volume of work (QCA 2006e). This may go against the reasoning applied by some schools in introducing it to boost attainment at lower levels and particularly C-D borderlines (Pouchaud 2005). Bell and Donnelly (2006) sent a questionnaire about applied science to schools in the spring of 2005, receiving 240 responses. They found that schools opted for applied science because it may increase examination scores (76% of schools) and that it met the needs of pupils better than other specifications (79%). Many schools indicated that they chose pupils from the middle attainment bands who were predicted D-C grades.

This is particularly acute, as many more able pupils would be encouraged to take advanced level sciences, in which applied science is not such a good platform towards more traditional courses. A lack of educational visits and vocational settings for a lot of the work done in schools was also noted by the QCA (2006e). Time constraints and a lack of organisations willing to host pupils were the main factors. In an educational environment where coursework is being cut back (QCA 2006e), applied science could be seen as an anachronism of a coursework dominant specification that is not being reflected in science 2006 where the coursework has been reduced in amount and assessed in controlled classroom conditions only rather than given to pupils to change and improve once completed. However, applied science could and should hold a niche as an optional addition to science 2006 where it provides an alternative form of learning for those who enjoy and prosper through its different approach.

2.2.6 Science 2006

Science became a core subject of the National Curriculum for all children aged 5-16 in 1989. The secondary school science syllabus by 2006, however, had not changed fundamentally since the days when science lessons were largely an option, chosen by the minority of children who hoped to proceed to science at A-level and university (House of

Lords 2007). The House of Lords Select Committee on Science and Technology discussed the role of science in the school curriculum. They were informed from several quarters that science in schools had to adapt itself to a dual role: to maintain its traditional and vital focus on preparing the most interested and talented pupils for science courses at university, yet at the same time, to equip *all* students with a basic grounding in the fundamentals of science, enough to make informed decisions based on scientific understanding. They continued by describing how science teaching should be more concerned with the nature and processes of science rather than the learning of established scientific facts. Thus they advocated a move from replacing pupil constructs with more scientific ones.

The select committee also decided to list some ideas of what exactly a child should hope to gain through a science education. Pupils should become familiar with stories about the development of important ideas in science which illustrate the following general ideas:

- Evidence is often uncertain and does not point conclusively to any single explanation;
- If an explanation predicts an event which would otherwise be unexpected, and this is then observed, this greatly increases our confidence in the explanation (e.g. Adams' predictions of the existence of [the planet] Neptune);
- That scientific progress can depend on careful and painstaking work, and also on creative conjecture (e.g. the roles of Franklin and of Watson and Crick in establishing the structure of DNA).

By considering some current issues involving the application of science, pupils should:

- Recognise that a person's views may be influenced by their professional and/or social affiliations;
- Appreciate that many things which we would like to understand cannot (yet) be explained fully in terms of a predictive theoretical model; because of the complexity of the systems involved, the best we can do is to identify correlations between possible factors and the *probability* of a certain outcome (such as the links between smoking and lung disease, or between saturated fat consumption and heart disease);
- Understand the ideas of probability and risk;
- Be aware of the range of factors which can influence people's willingness to accept specific risks;

- Be able to distinguish between technical issues (what is possible) and ethical issues (what ought to be done) when considering issues involving science and technology.

The House of Commons Science and Technology select committee on science education (14-19) (2002) complained that:

> Current GCSE courses are overloaded with factual content, contain little contemporary science and have stultifying assessment arrangements. Coursework is boring and pointless. Teachers and students are frustrated by the lack of flexibility. Students lose what enthusiasm they once had for science, (p.6).

Watson, Goldsworthy and Wood-Robinson (1999) had previously considered that a restricted set of investigations do not represent science. The QCA (2007b), and Murray (2007) also agreed, the latter describing how it had become boring and irrelevant for students. The House of Commons Science and Technology select committee (2002) backed up their statements by quoting teachers and pupils at various schools who concurred that the drive towards passing fact laden exams drove the teaching and learning process at the expense of problem solving skills and 'interesting' science (p.16). Similarly, they described how coursework is 'taught and carried out to maximise exam results rather than to develop skills' (p.21).

A study by Donnelly (2000) investigating teachers' views concluded that National Curriculum science had 'reduced the flexibility which allows teachers to respond to pupils' needs and interests in the teaching activities they use' (p.27). It was previously claimed that many pupils had a poor understanding of science, and many dropped the subject as soon as was possible (Gott and Johnson 1999). Monk (2006) opined that coursework was bolted on as a piece of 'experiential learning' to the teaching of content as 'transmission learning' (p.121).

Other evidence of disquiet with the state of science came from the Science Museum of London (2006) who published a survey in 2002 where over 2000 pupils between the ages of 14-19 were asked their opinions of GCSE Science as it was. The findings can be summed up as four main points:

1) 60% of pupils felt that smaller class sizes would most improve GCSE grades in Science, combined with relating science to everyday life.
2) 47% felt there should be more emphasis on understanding WHY things work rather than HOW in GCSE Science.
3) 75% of students want more real life practical examples to help them in their science, with 79% of students believing practical and experimental work help them to understand science topics.
4) 86% felt that students should be given the choice to do dissection in Biology

Around the same time as the Science Museum survey, a statement from the House of Commons select committee for Science and Technology (2002) outlined perceived problems with coursework in the present system of GCSE science:

> Coursework at GCSE science needs a radical rethink. This is the responsibility of the awarding bodies but it is obvious they are going to need significant encouragement from QCA ... If there is no significant change to investigative work they should enter into immediate discussions with teachers and awarding bodies about how coursework could be changed to encourage more stimulating and engaging practical work in schools (p.34).

They continued to state how the new (science 2006) GCSE will 'reconcile the tension between preparing students for further study and further life' (p.38).

How could the science curriculum be revitalised? Gott and Duggan (1999) had argued for a curriculum based on three elements: The first is recall: the ability to know scientific 'facts' as substantive ideas, and undertake basic measurements, such as reading a thermometer as a procedural idea. Secondly, instrumental understanding or 'know how' is the ability to understand what is happening if for example an electric circuit is suffering faults, or as procedural understanding how to use a fair test. This know how would only be applied in the context of problem solving. Fundamental understanding and application involves grasping the fundamental ideas of science and applying them in experimental situations. Gott and Duggan (1999) claimed that few pupils were approaching fundamental understanding.

A National Curriculum review was held in 2000. The University of York Science Education Group (UYSEG) was commissioned to develop a science curriculum, eventually entitled 21st century science, in collaboration with the Nuffield Foundation and OCR. Burden (2005b) wrote of the reasons for the inception of 21st century science:

> Increasingly, questions have been raised about the suitability of the [pre 2006] curriculum. Students, teachers and parents have reported dissatisfaction and there is also considerable concern about the falling take-up of some science subjects post 16 (p8).

21st century science involves a compulsory scientific literature core. This should lead its learners to understand science in the media, be able to discuss science, appreciate what it tells us about the Earth and universe and the impact science has on everyday life (Burden 2005b, Millar 2006 and Hannam 2008). The new science should encourage students to study the subject at a higher level, and give a broad understanding of science to all pupils (Wicks 2007). It may achieve this by giving pupils major scientific concepts to grapple in sections entitled Scientific Explanations. This is apparently set at a level where pupils may not get lost in unnecessary complexity and switch off. The second strand, entitled 'Ideas about Science', works by introducing pupils to data and limitations in it and the scientific community, amongst other things. They are taught in nine modules that contain one or two or Ideas about Science. The Ideas about Science section uses case studies to make pupils aware of how scientific knowledge is advanced, rejected and argued about. Some new modules, such as epidemiology, and health sciences were introduced (Millar 2006). In terms of coursework, pupils have to do a case study, e.g. the biodegradability of plastic bags, and an analysis of data. Teachers' comments about the course included a wish to increase the amount of practical work (Burden 2005b, Millar 2006). 21st century science involves a one GCSE subject course with additional science modules available to take pupils up to two GCSEs. These can be academic, or an applied route is available (Millar 2006).

The pilot scheme for the introduction of 21st century science did not happen with the introduction of applied science (Millar 2006). The QCA invited secondary schools to participate in the three year programme from September 2003. A total of 78 schools responded, reflecting the mix of urban, suburban and rural schools throughout England. The average of these schools' examination results was close to the national average. In one third of the schools, all students followed the course, in the rest, only a number of classes did. The success of the course was evaluated by giving out questionnaires to teachers attending residential training programmes in twenty first century science towards the end of the first year of the pilot. A total of 40 teachers completed questionnaires. The results indicated that teachers found the course successful in improving scientific literacy, with nine describing it as very successful, and 26 successful at doing so. Most teachers found the course different to previous science specifications, with 20 describing it as very different, and 19 as different. Many teachers were positive about the effect of the course on students' interest in science, with six saying it was much better, and 21 saying better. Only four described their students' interest as now worse. Six teachers enthused about the quality of the coursework option, whereas 21 particularly liked the relevance of the course, and links to the media, and 20 were happy with the ICT resources provided. Some teachers were also positive about their student's views of the course. Two thirds of the sample indicated that their students were more positive than for previous courses. It is important to realise that these results were taken from teachers who had been trained to teach the new course, and that a new initiative, like 21st century science, may produce positive results due to the heightened interest and motivation of those delivering it (Millar 2006). However, the results, if initial, do point to a positive first appraisal of 21st century science.

The use of newspapers and current media articles in the classroom were discussed by Jarman and McClune (2005). They considered the virtues of newspaper science journalism, stating that 'the prose is compelling, certainly more compelling that a GCSE textbook' (p.8). This would possibly comply with the 21st century science core requirement that a pupil should be someone who 'understands the essential points of media reports on science-based issues, and reflects on the information in, or crucially omitted from, such reports (Burden 2005b). Jarman and McClune (2005) continued by relating how scientific journalism is up to date, contemporary and written for lay audiences. A complaint about how some TV documentaries tend to 'gloss over the provisional nature of our knowledge' was made by Taber (2007 p.7). He also noted how some programmes show scientists at work disagreeing, changing their minds and formulating hypotheses. This he described as showing the tentative nature of scientific evidence. The House of Lords select committee on science and technology (2000) stated that 'Once they leave school, most people get most of their information about science from TV and the newspapers. The House of Commons select committee on science and technology (2000) reported that 'research has shown that the knowledge of science that school currently provides is of little value when considering these [media] issues' (p.37). However, through the media the image of science itself had taken a battering through the reporting of such things as Chernobyl and DDT. Added to this, films such as the Back to the Future series may have perpetrated the myth of the 'mad scientist' with their portrayal of such characters (Millar and Osborne 2000). A positive public attitude to science was found by Hulin (2008). 82% of people questioned in a national survey claimed to be amazed by the achievements of science, and 43% found accessing scientific information to be easy, with the internet playing a significant role in this. Pupil views of GCSE science are discussed in section 2.2.7.

Jarman and McClune's (2005) article was written to raise awareness of a project entitled News in Science Education that aimed to help teachers 'as they encourage their students to engage with science in the media and do so with a degree of criticality' (p.8). This has become a cornerstone of the science for the 21st century specification. The House of Lords select committee (2006) found pupils in favour: pupils felt 'there was too much learning of facts and not enough about the processes and applications of science. There was a general consensus that science would be more attractive if it could show itself to be relevant to current issues' (p.21). A criticism of how educators themselves may worry about how learning about, for example, genes or nuclear fission may affect public discourse about such issues came from Cobern (1995). He commented on the implicitly powerful objective nature of scientific ideas. Getting pupils to discuss science in the media was both 'laudable and unexceptionable' (Allen 1999 p.13).

The approach of Jarman and McClune (2005) and science 2006 was indirectly criticised by Childs (2006) and by Wright (2006). Childs (2006) researched newspaper reporting of the MRSA 'superbug'. Newspapers, she described, are 'not known for their accuracy and the reporting of MRSA proved to be no exception' (p.253). She calculated an average of 2.59 errors per story with a maximum of 14.65 from a 'well known red top' (p.253). Newspaper inaccuracies most commonly covered such topics as dirty hospitals being the main cause of MRSA, and exaggerating the number of people infected. This Childs (2006) dubbed 'sensationalism' (p.255). Public confidence in topics such as genetically modified crops and biotechnology was falling, possibly due to media reporting, according to a study by Napper (2006). A report on media generated views of food and health, unpicked a lot of half-truths about organic food and other examples of 'bad science' (Feldman and Marks

2006). Concern was expressed over anti-science attitudes in modern society by Cobern (1995), which could be fuelled by such reporting cited above. The media could be fuelled partly by a lack of knowledge caused by their lack of scientific education.

The QCA was asked by the DfES to revise the Key Stage 4 programme of study for science following the trials of 21st century science. Burden (2005a) wrote that the aims included 'making science more relevant for all students' (pp.8-9) This resulted in a new range of science GCSEs from 2006, aiming to ensure that:

- Pupils study science that is relevant and up-to-date; and
- there is choice in the courses that pupils take to prepare them for different career routes post-16

The most obvious new change was that the content pupils have to know became equivalent to one rather than two GCSEs. This was reduced in the specification from ten pages in 1999 to one in 2006. As Monk (2006) pointed out, 'QCA has heeded science teachers' complaints of content overload' (p.119).

Pupils could then take one of a range of qualifications to complement the core GCSE science they have to learn; additional applied science, additional science, biology, astronomy etc. This dichotomy of choice has pleased some correspondents; 'the possibility for choices of different kinds of science courses that are appealing and relevant for all students are clearly attractive' (Cutler and Fenton 2005 p.16). So, pupils with a flair or disposition towards coursework, for example, could take applied science as their additional option, whereas those looking to continue in the sciences at 16+ would choose a more academic additional science. The challenge would be for pupils and their teachers to identify their strengths and weakness and ascertain which path they want to take at an early stage.

The Sc1 component of the curriculum became How Science Works (Monk 2006) with coursework assessed by ISAs (independent skills assessments) and PSAs (practical skills assessments). Alongside providing information about such matters as practical enquiries and data measuring, a section was introduced concerned with the nature of science, with teachers encouraged to plan schemes that cover this area. This was compared by Monk (2006) to the previous curriculum that reduced science to 'empiricism and inductivism' (p.120), which simply meant the collection of data to demonstrate accepted scientific ideas. Pupils in the 2006 scheme may have been encouraged to debate the 'facts' of science and bring their own viewpoints more into lessons. This concurs with some of the earlier recommendations of the 2000 House of Lords Select Committee on Science and Technology.

The specification used during this study was AQA Science A (AQA 2005b). This provides pupils with a modular scheme of assessment coupled with a coursework component. The coursework comprises 25% of the marks. The exam-based component is assessed by a series of examinations in the November, March and June of the course. Each examination is multiple-choice, lasts thirty minutes and counts for 12.5% of the total mark. There are six examinations in total covering two modules each of chemistry, biology and physics. An alternate strategy is provided by the AQA B syllabus (AQA 2005c), which tests biology, physics and chemistry separately by forty five minute written short answer examinations, which can be taken in the January and June of the course.

Coursework became the Centre Assessed Unit. It is comprised of what AQA (2005b) termed ISAs or independent skills assessments. They were designed to test 'fundamental ideas, observation, investigation design, measurement, data presentation, identifying patterns in relationships and any social aspects of scientific evidence' (AQA 2005b p.64). In many ways they are radically different from previous incarnations of coursework. Any number of ISAs could be undertaken from any of the course components and only the highest mark would count. ISAs could include work from any aspect of the course, which could reduce the problems of homogeneity amongst previous pieces of coursework previously outlined by McAteer (1998). From the summer of 2007, ISAs replaced the modular science coursework (detailed in section 2.2.6) in the separate science GCSE specifications.

ISAs are conducted in forty five minute lesson sessions under 'controlled' conditions (specified by AQA (2005b) as pupils working alone and in silence). Before the ISA commences the pupils complete an experiment, in groups or alone, in order to generate data, including a graph and results table. They use this data to answer an ISA question sheet supplied by the exam board and worth between 14-20 marks. They then complete another ISA sheet with data from the same topic in the specification supplied by the exam board. This is worth between 14-20 marks.

Alongside this the teacher provides a mark called a PSA or practical skills assessment by AQA (2005b). This is judged throughout the year and is based on a pupil's 'implementation of practical skills' (p.68). It is marked on a scale from 1-6 using materials appropriately, carrying out methodical and organised work, and working safely with regard to the environment and living organisms. The maximum score for ISAs and the PSA is forty. The QCA coursework report (2006g) pinpointed judgement of such things as practical problem solving as being hard to make.

This approach seems to have been a lot less problematic for many teachers and students than previous coursework. There are none of the problems of protracted pieces of work taking up inordinate time (Gott and Roberts 2004). Having the work completed in lesson time and then sent for assessment has negated the problem of internet plagiarism. They could be taken any number of times (at the time of writing), which caters for pupils who may have been absent for some assessments. There is no need for an excessive amount of writing, which can put some pupils off coursework.

Science 2006 could give an opportunity for teachers to start 'reclaiming investigation for science learning by teaching science through investigation, and not as divorced from it' (Toplis and Cleaves 2006 p. 82). They emphasised the importance of allowing a lot of time to complete and reflect upon investigations. Using the written ISA tests would be more efficient, and free up more time for teaching (Gott and Roberts 2006) The key stage 4 National Curriculum Program of Study for England and Wales states that pupils should be taught to 'plan and test a scientific idea, answer a scientific question, or solve a scientific problem' (QCA 2006b p.37).

The idea of producing a school populace willing and able to discuss science was an ambitious aim and one well worth pursuing, 'but the challenge involved in this aim should not be glossed over' (Adey (1999 p.13). Brandon (2006) claimed that the sweeping scientific complexities of the 21st century science syllabus would not enable people to discuss scientific issues, as they would not have the theoretical background or the numerical or data processing skills needed. Exam bodies have suggested specific practical tasks for science 2006 coursework assessments that seem to echo the formulaic assessments of the past (Toplis and Cleaves 2007). This goes against the National Curriculum in 2004 (2007), which indicated a change towards more open ended practical work.

The course was defended in the House of Lords select committee report (2006) where it was claimed that 'the majority of witnesses broadly welcome the new GCSE courses, particularly the learned societies' (p.22). The report claimed that teachers have enthused over the opportunities to make science more relevant and interesting. This is shared by the research councils who saw science 2006 as allowing them to take more ownership of their subject (House of Lords 2006).

As a footnote to considering the different specifications on offer, it is worth considering the words of Slingsby (2006): 'Dedicated educators have always tried to make the most of whatever framework they have had to work with' (p.283).

2.2.7 Pupil views of the GCSE science curriculum

A focus group study to ascertain, from a pupil perspective, the role and value of the pre applied and science 2006 GCSE science curriculum was conducted by Osborne and Collins (2001). They worked with 20 focus groups, comprising a total of 144 pupils, all of whom were aged 16. The pupils were studying in secondary schools in Birmingham, Leeds and London, which had GCSE results within 15% of the national average. Osborne and Collins (2001) taped, transcribed and coded their focus group discussions, and produced 430 codes. They then used data analysis to find the frequency of some codes.

The majority of students valued having a science qualification, and believed that science learning was important for their future careers. There was 'a general agreement that many aspects of science were hard' (Osborne and Collins (2001 p.449) amongst students. Approximately half of the students believed that the science curriculum was rushed, a viewpoint later echoed about the science curriculum by students in Cowie (2005) and about coursework by students in Toplis and Cleaves (2007) study, in which pupils were concerned about a lack of time to get accurate experimental results. Many pupils also felt that the science curriculum was content driven, with more emphasis on factual recall than other subjects. Just under half felt this way. Some pupils also expressed dissatisfaction with the repetition of tests and experiments they had experienced, whereas others complained of a lack of discussion. No numbers were given to state exactly how many focus groups or pupils had expressed these opinions and support the findings. However this research offers an insight into how the pre science 2006 and applied science curriculum were viewed by pupils.

Student views of their science curriculum were researched by Murray and Reiss (2005). Over 350 students, aged from 16 – 19 designed a web-based questionnaire about the science curriculum. The survey was online between December 2001 and February 2002. A total of 1493 questionnaires were completed, 73% by 16-19 year olds, 23% by 14-16 year olds, and the remainder by people aged more than 19. Girls accounted for 66% of respondents. Many pupils enjoyed experimental work, and found it useful for learning, suggesting that experiments at least, played a significant part in the curriculum (Murray and Reiss 2005). Despite having a majority of respondents aged over 16, the research outlines the significance to pupils of experimental work in science.

The views of pupils concerning GCSE coursework were investigated by Toplis (1994), and Toplis and Cleaves (2006, 2007). They sampled a wide range of schools; nine were used in 2007. Toplis (1994) interviewed ten small groups of between two and four pupils from three schools. Toplis and Cleaves' research was conducted in nine schools across two counties in England on pupils aged 14-16. Their findings focussed on four main factors: time, assessment, apparatus and the role of the teacher: Pupils were worried about time acting as a limiting factor on their work. Many pupils felt that insufficient time prevented getting accurate results in their experiments, without experimental errors. Others were concerned that the amount of practical work they were doing had declined from what they did at pre GCSE level. It was concluded that most schools used practical work as a summative assessment tool, which only dissatisfied pupils (Toplis and Cleaves 2006). In their 2007 report, they considered adding a formative element to investigations. Teacher professional judgement and decision making should replace prescriptive assessment through coursework:

> Where teachers set the questions, pupils lose the real spirit of investigation. When questions that can be investigated arise along the way, pupils can be encouraged to start thinking about how to address these questions, and to start piloting these ideas. (p94).

Teachers, some pupils considered, were training them to do investigations to get the right results without teaching them an understanding of the science behind them, to which they saw little benefit.

Research in Northern Ireland found that 85% of pupils 'gave a very positive response to the question about enjoying investigative work' (Jones, Gott and Jarman 2000 p.29). Research by Nott and Wellington (1999) backs this up with many pupils in interviews and questionnaires being very positive about how they enjoyed practical science.

Pupils in Northern Ireland enjoyed the independence and empowerment afforded by investigative work and the opportunities to do different and more detailed practical work (Jones, Gott and Jarman 2000). Only 11% of their study expressed dissatisfaction, mainly in the process of writing up and submitting the work. 79% of pupils thought that they had learned through coursework. They noted procedural understanding – how to plan an experiment, and especially conceptual understanding of the science behind it as what they had learned. Of these pupils, 'more indicated that they had learned knowledge relating to the facts of biology, chemistry and physics rather than to the procedures of science' (p.32). Many found carrying out the experiments straightforward but the planning was found to be most difficult by 43%.

A pupil and a teacher forget that what the pupil sees conveys no information until the pupil knows beforehand (presumably by being told by the teacher) the kind of thing the pupil is expected to see (Medawar 1982). Toplis and Cleaves (2006) stated that 'pupils are experiencing a divorce of science investigations from learning' (p. 77). They described coursework investigations as 'didactic approaches with some aspects of 'discovery' learning in which the outcome is predetermined by the teacher and may be obvious to the teacher' (p.79). Their investigation was concerned with pre-science 2006 science coursework but if this is the case then in courses which are 66% coursework based, i.e., applied science, pupils could be doing very little learning.

Many pupils believed they were overloaded with coursework, according to an earlier study by Bishop, Bullock, Martin and Thompson (1997). Toplis's (1994) report mentioned stress as another factor with some pupils indicating time constraints and a lack of understanding of the concepts involved increasing their stress levels.

Coursework and learning at undergraduate level was investigated by Gibbs and Simpson (2004). They found coursework grades to be on average higher than those achieved by examination. Their study found students at this level showed a preference for the 'fairer' approach that coursework allows alongside the wider range of abilities they perceived it measured. It was concluded that coursework based learning is a better predictor of long term learning than exams, presuming that 'the kind of learning that coursework involves has long term consequences while the kind of learning involved in revision for exams does not' (Gibbs and Simpson 2004 p.4). At school level this could be connected to many pupils having a 'life world' and a 'school world' (Littledyke 1998). This means that at school they may learn in a positivist fashion to satisfy the needs of exams and assessment. Their life model contains the views, beliefs and theories they believe. Therefore what they learn in the school has no value to them personally and is later forgotten, much as Gibbs and Simpson (2004) found with undergraduate exams. Cobern (1995) thought that students tended to compartmentalise the scientific concepts that did not fit in with their views and retrieve them for exams. Although Gibbs and Simpson's (2004) research is based on university education, it is an important pointer to attitudes to coursework of more able learners and a benchmark against which GCSE pupil opinions can be viewed.

2.28 Summary

Through investigating the literature concerning coursework in the science curriculum, I have investigated the range and definition of a coursework investigation, and discussed the arguments for and against coursework. I have explained how coursework has developed along with the National Curriculum, and the type of coursework delivered through the modular, applied and science 2006 specifications. The literature has highlighted problems with the modular science approach to coursework in that it was reduced to a few formulaic investigations that may have made pupils 'jump through hoops'. Science 2006, with an emphasis on science in the news, and how science works, was brought in to replace it. The coursework investigations attached to science 2006 were to be completed in examination conditions. Applied science was introduced to give a more vocational, coursework based approach to GCSE science education. The literature contained research concerning pupil views of the science curriculum up to 2007 and including the now removed modular specification. However there was no research measuring the impact of science 2006 and applied science including the perceptions of pupils and teachers to those specifications, and their effectiveness in terms of pupil learning.

My perspective as a teacher involved in planning, teaching, and assessing a changing curriculum has been in favour of a coursework based approach, particularly where the work can be completed, assessed and improved by the pupils, as it encourages collaborative and investigative skills, and can motivate pupils as they can see their grades improve as they complete, and improve their work. This has sharpened my investigative focus to ascertain to what extent these views are shared by pupils and, and to what extent coursework in GCSE science can realise those aims.

Part Two: Teaching

In this section, I have investigated literature concerning the opinions of teachers towards science in the National Curriculum, coursework, how policy affects teaching, and how teacher training can influence the teaching of coursework.

2.3.1 The views of teachers

The impact of the National Curriculum on science teaching and teachers was researched by Jenkins (2000). His data came from questionnaires that were sent to a random sample of 500 secondary schools in England and Wales during the summer of 1998. Teachers with less than ten years experience were excluded, as they did not have experience of science before the introduction of the NC. The response rate was 59.2%. He found that, in general the NC helped teachers to clarify their lesson objectives, and since its inception, they took more time in planning lessons, and were more likely to collaborate in planning lessons and schemes of work. His specific findings were given as percentages: 19.2% of respondents felt that the curriculum had narrowed, limiting their options for teaching forensic, cosmetic, or land based science. 14.6% said that they had less time for lab experiments, as they needed time to cover the content prescribed by the NC. 19.6% thought that pupils enjoyed science less since the inception of the NC, and 42.7% were unhappy with the marking, moderation and administration involved with the coursework component, which changed very little until the introduction of applied science and science 2006. Jenkins' (2000) study included a large amount of data and provides a viewpoint on how the NC had affected their teaching.

The opinions of teaches in Scotland to teaching investigative science, including assessed coursework were researched by McNally (2000). He opined about a lack of teacher perspective in the literature. His methodology was to organise a symposium for science teachers where they could share their reflections. A total of 16 teachers, at 14 schools were involved, and their discussions were recorded, transcribed, and collated. The numbers of teachers espousing particular views were not ascribed to the results. Teachers generally viewed investigations as being an important part of science, and that pupils enjoyed completing them. However, there was no evidence that teachers saw such work as more effective or important for learning than non investigative work. Teachers were also aware of pupils who built up scientific constructs out of the school environment, and did not use them in the classroom, for example in fixing broken car engines. This is similar to Littledyke's (1998) assertion that pupils have a 'life world' and a 'school world'. There was a feeling that schools should be equipped to deal with 'real life' investigative science, and a realization that this would be difficult to do, in terms of finding resources and fitting in with the curriculum. McNally's (2000) research encompassed the views of one group of teachers, which may or may not represent those of their peers, and may have been subject to the opinions of a few more vocal participants.

Research in Northern Ireland by Jones, Gott and Jarman (2000) found many teachers bemoaning how much pupils needed leading to do investigative work and complaining of how little pupils gained from the work. However 60% of the teachers they spoke to were positive about coursework, particularly in relation to developing pupil skills in problem solving activities.

The National Endowment for Science, Technology and the Arts (2006) reported on a poll they commissioned that took results from over 500 secondary schools: Most teachers (84%) considered that learning through science enquiry was very important, with 87% agreeing that it can have a significant impact on pupils' performance. However, 64% of science teachers, nearly two in three opined that the biggest barrier to more science enquiry work was a lack of time within the context of current (pre-science 2006) curriculum arrangements.

A general study of teachers' views was reported in the QCA coursework review (2006e). They interviewed 70 teachers, head-teachers, local authority representatives, and other interested parties at a series of seminars concerning coursework assessment. They concluded that teachers were mostly positive about coursework, speaking of how it gives pupils independent working skills, and is less stressful than exams. The time consuming, deadline-meeting factors associated were identified as drawbacks. 82% of teachers felt that pupils did not use the internet to help with coursework, a factor highlighted by the QCA for reducing coursework. Added to this, 66% of teachers would not welcome the removal of coursework.

Earlier research by the QCA (2006c) found just over 50% of the 138 science teachers they questioned agreed that coursework is a valid means of assessment. 45% disagreed. Science teachers also found marking time, inconsistent coursework practices and authentication issues were the biggest problems with coursework. Also 64% of teachers let their pupils work unsupervised.

2.3.2 Staff continued professional development and training in teaching and assessing coursework

New science syllabi require different assessment criteria, which need to be learned. Bell and Donnelly (2006) considered how teachers had been trained to assess coursework for the applied science specification. For a course with such an emphasis on teacher assessment of coursework, the examination bodies, such as AQA, were provided with government money for teacher training. Most training concentrated on the demands of ensuring coursework was assessed correctly, rather than the aims, management and pedagogy of the course (Bell and Donnelly 2006).

The criteria that underpin effective continued professional development (CPD) were investigated by Carter and Halsall (Halsall 1998). They found that staff should be encouraged to develop their own learning objectives, and these should be interlinked with school development needs. The House of Lords select committee (2006) commented on the poor take up of subject specific CPD by science teachers, something they considered essential with the pace of scientific progress. Over the course of a career the state spends on average between two and four million pounds on each teacher (Finegood 2005). Therefore, wise investment in appropriate training would appear prudent. Finegood (2005) cited research completed by the Wellcome trust, which recognised that science teachers suffered from a low level of available CPD, which was compounded by a low level of satisfaction in CPD: 35% compared with 48% for teachers of other subjects. Alongside this 72% of science teachers were found to want more subject-related CPD, 12% higher than non scientists. Research in the USA reached similar conclusions, finding in service training to be of generally poor quality and not addressing teacher needs (Boone and Chase 1997) Furthermore, Finegood's (2005) study found that:

> ...a half of all secondary science teachers had no subject related professional development experience in the past five years' yet paradoxically participants in the

study suggested that subject-related CPD offers the greatest degree of personal benefit at all career stages (p.8).

Alongside this, 95% of teachers thought CPD could influence their teaching and 'broaden their horizons' (Kibble 2007 p.5).

The House of Lords select committee (2006) recommended compulsory subject specific CPD for science educators. The House of Lords select committee (2006) recommended sharing best practice or visits to science learning centres. Also 'senior managers have engaged in twice as much external CPD over the past five years than classroom-based colleagues' (House of Lords select committee (2006 p.9) In general, senior staff have a far lighter teaching load, if any, when compared to classroom teachers. Nor do they have substantial assessment demands. Some other statistics from Finegold's (2005) research are that 87% of science teachers agreed that CPD increases their job confidence and 71% believed in a resulting improvement in morale.

Effective CPD could boost the morale and confidence of teachers dealing with coursework. Science CPD in 15 secondary schools was analysed by Lydon and King (2009), using Likert scale questionnaires given to, on average, ten teachers per school. Their findings suggested that short, 60-90 minute CPD sessions may produce lasting changes in practice. By applying this to coursework, effective training in marking and assessing coursework could be delivered without a large impact on time. The QCA (2007) stated that teachers were enthusiastic about training undertaken by exam boards, relating to coursework marking and moderation. They also found concerns as to the timing and frequency of such training, and that many teachers did not attend.

There are real recruitment and retention problems associated with science teachers and the fact that most science teachers are biologists, who may benefit from some training in the physical and chemical sciences (Reid, Martin, Delaney, Cloke, Bishop and Dodsworth 2003, the House of Lords select committee 2006). Reid et al. (2003) analysed 134 postal questionnaires from teachers in two separate regions of the UK, and interviewed two focus groups containing a total of 16 teachers from February – October 2002 to reach this conclusion.

2.3.3 Policy issues

Implementing educational change and improvement, such as the implementation of new science GCSE specifications, can be seen from different viewpoints. Littledyke (1997) described political (as external political influences), technical (as strategic responses adopted by the school to these influences) and cultural (how the people in the school are affected) perspectives that can influence and effect change. Riley and Louis (2000) wrote of the issue of leadership and identified the role of a teacher planning a change amidst the 'political and social environment in which change must be enacted' (p.4). Robson (1996) considered the political aspects of evaluating practice. He went so far as to say that particular outcomes may lead to 'jobs on the line' (p.183). Change can be externally directed from central government as many changes are now. Internal change such as introducing new curricula should be done, but participants should be prepared to fail at least the first time it is done, but with the expectation that the second time it will be better after a review and the third time it will be done well (Brighouse 2006). With the changes in science specifications, teachers may not get a chance to do new things a third time. Carter and Halsall (1998) considered government statements from 1979 and the Education Reform act in 1988. They found that concepts borrowed from the free market such as economy, efficiency and effectiveness have changed the role of the teacher from one concentrating on how to teach to one concerned with the effective performance of themselves and schools. This indicated a change in the role and views of an individual teacher as directed from above. This could lead to teachers believing that change only comes from above and that their actions are only reactive, responding to change rather than helping to instigate it based on their professional practice (Carter and Halsall 1998). There are aspects to this research that are concerned with the policies of change, of implementing new curricula and ideas and how this affects pupils and teachers.

Ofsted (2004) pointed out that:

> The role of the senior management is crucial in developing a strategy for improvement that takes into account the context and specific needs of the school. The strategy might involve a whole school focus on teaching and learning, on improving the ethos or on improving learning support, but is more likely to involve a package of measures. Sensitive leadership is often needed to raise the expectations of pupils amongst staff, parents and the pupils themselves. (p.15)

They added that a successful school should be one that encourages learning with a positive ethos and high expectations of learning and behaviour.

Research into how policy affected assessment for learning was conducted by Harlen (2004) (section 2.5.4). There is a statutory requirement in England for assessment in certain subjects at the end of the Foundation Stage (pre key stage 1) and at the end of each Key Stage. In all cases, this included a component of assessment by teachers; at Foundation Level all assessment is by teachers. Policy occurs at GCSE level for students, when teachers' assessment of special tasks or projects is used in whole or in part for certification purposes, for example the practical skills assessment introduced in science 2006. Harlen (2004) reported how 'distrust of teachers' judgements led, in 1992, to the government in England and Wales limiting the proportion of credit that could be awarded on the basis of assessment by teachers.' (p.15). This has since been rethought, due to evidence that summative judgements can boost student motivation, hence the use of summative assessment in science 2006.

Attitudes to assessment have changed over the years and this has trickled down to teachers in the classroom, as can be derived from Harlen's (2004) research. Older colleagues delight in telling me how every idea in education comes full circle and it seems that this has happened with summative assessment. Policy may come from the Department of Education but it is teachers and students in the classroom who must deal with it in practice.

2.3.4 Summary

In summing up, many teachers believe that scientific investigations are important for learning (McNally 2000, Jones, Gott and Jarman 2000, The National Endowment for Science, Technology and the Arts 2006), particularly in terms of giving pupils problem solving skills This agrees with my perspective on the positive virtues of coursework. McNally's (2000) study found that many teachers believed that investigations were no more effective for pupil learning than other forms of work. Time constraints were identified by many as a limiting factor to good investigative coursework (Jones, Gott and Jarman 2000, QCA 2006e).

It would seem that CPD is not having the desired affects, if it is being utilised at all according to the reports quoted in section 2.3.2. Therefore teachers may not be receiving the training they need in order to deliver and assess new specifications. Teachers also may feel that the changing specifications are being forced on them, and their only role is to deliver what they are told to (Cater and Halsall 1998).

There is a lack of literature dealing with the views, perceptions and attitudes of teachers about the coursework components of science 2006 and applied science, and the effectiveness, in terms of pupil learning, of those components. This has developed my research focus towards these areas.

Part 3: Learning

This section explores aspects of learning through the two dominant theories for learning science: constructivism and positivism. It also explores what motivates learners, active learning, possible differences in attainment between male and female students in coursework and examination scores, and how pupils can collaborate in the form of coursework collusion.

2.4.1 Learning through GCSE coursework

The APU studied the skills pupils needed to complete a scientific investigation concerning measuring the resistance of a piece of wire (Gott and Duggan 1995). They found that given a fully connected circuit, only 9% of 15 year olds could correctly add an ammeter to measure current and a voltmeter to measure voltage. 17% used the ammeter to measure voltage whilst 39% used the voltmeter to measure current. Using written answers, it became apparent that pupils chose randomly between volts and amps for the units. The skill they used was in connecting the meters to the circuit, not working out which should go where (Gott and Duggan 1995 p.68). Yet, a lot of pupils do an investigation involving measuring voltage and amperes correctly numerous times to gain high coursework marks. Kuhn (1996) stated that 'instructed to examine electrical or chemical phenomena the man who is ignorant of these fields but who knows what it is to be scientific may legitimately reach any one of a number of incompatible conclusions' (p.4). This may sum up how pupils with little theoretical knowledge seem to follow a process that is 'scientific' to draw a conclusion. AQA (2004b p.142) asked pupils while obtaining results 'to collect sufficient systematic and accurate evidence and repeat or check when appropriate'. Doing this would give them six out of a maximum eight marks.

Another skill essential for many investigations is that of graphing. To obtain a modular science analysis mark of six out of eight, pupils would draw a graph with a line of best fit with five or more points made from three sets of results from which an average has been plotted. Yet, the APU state that by the age of 14 (year ten) their investigation showed less than half of the pupils sampled could draw a line of best fit on a graph. Further to that there was confusion by pupils between whether to plot line and bar graphs (Gott and Duggan 1995 p.68). Yet, as before, pupils manage to obtain high marks for their analysis. Some pupils learn the skills of good graphing, yet others must be told how to graph for a specific piece of coursework and do not retain the skills of graphing. Some skills of coursework are retained and used later, whilst others are lost.

Concentrating on what pupils learn rather than how they learn, can lead to superficial learning that pupils are unable to apply to other situations out of the classroom (Littledyke 1998). Effective learning in a constructivist manner should include allowing meaningful constructs to be built up by pupils that have meaning to the learner and concur with the scientific thinking demanded of the curriculum.

A model for describing curriculum content and the facts and procedures that pupils must comprehend was outlined by Gott and Johnson (1999, table 2.4). They described the 'facts' and ideas of science as 'substantive content' and the skills involved in manipulating instruments and interpreting results as 'procedural ideas' (p.24). At a basic level this involves memorising facts by positivist teaching approaches and rote learning.
A higher level of understanding is instrumental understanding. This involves the learner knowing 'enough about what is going on to have a feeling of control' (p.24). They describe this as the level at which many applied scientists such as farmers and electricians operate. It is a level of understanding enough to solve problems but not to explain the ideas and theories beneath the problem they are solving. Fundamental understanding refers to the capacity to understand the underlying science used to explain events and phenomena. It also refers to the ability to apply scientific understanding to new situations. Gott and Duggan (1995) commented on how few pupils reached this level of understanding. These subdivisions of curriculum content were applied to coursework based learning by Gott and Roberts (2006). They described how procedural ideas are the 'thinking behind the doing' (p.47) and include the judgement of whether enough readings have been taken, or if a sample is large enough to be valid. Thus, there is a knowledge base as well as the practical skills of assembling and measuring data from experiments. By combining and

processing substantive and procedural knowledge, to develop conclusions and theories, pupils develop and use higher order investigative skills and fundamental understanding and application. The work of Gott and Duggan (1995) and Gott and Roberts (2006) provides a useful breakdown of how levels of scientific learning can be categorised which can be applied to the different curricula within this thesis.

Table 2.3 A model to describe curriculum content

	Substantive Ideas	Procedural ideas
Recall	Facts such as the formulae for water or the units of measuring force.	Skills such as the use of a thermometer correctly and accurately, or the setting up of a complex experiment following a 'menu'.
Instrumental understanding	Understanding of electrical circuits in fault finding situations, or an understanding of the benefit of seat belts without necessarily being able to explain the forces and accelerations involved at a fundamental level.	Understanding of the idea of a 'fair test' or the interpretation of data without necessarily being aware of the complex links that must be formulated if data are to be judged as to their validity and reliability. A working knowledge of how to collect and use evidence.
Fundamental understanding and application	Ideas such as the particle model, electrical interactions between particles – 'bonding'. Gravity, and their application to the explanation of phenomena such as the forces involved in kicking a football and the resulting motion.	Ideas such as the importance of quantification, measurement, errors, experimental design, use and interpretation of tables. Validity and reliability are the key underlying ideas that can be applied to issues such as the critical interpretation about BSE/CJD, or nuclear power.

(Taken from Gott and Duggan 1995 p.24)

Table 2.4 shows a range of facts and scientific truisms that can be applied. There is no concept of creativity, the engine of scientific change. As Monk (2006) considered, we could separate the 'what is happening' from the 'why it is happening' and using debate and discussion to answer them rather than just present a parade of facts. The lack of creativity in school science was lamented by Fox (2006) who claimed that it is 'at least partly responsible for turning off from science the very creative, divergent thinkers that should be our future scientists' (p.45).

Looking at table 2.4, it becomes apparent that instrumental understanding may apply to anyone who makes an attempt to explain something but without having in depth scientific knowledge to back it up. It is such non-specialist interpretations of phenomena which people make all the time in all sorts of situations. Presumably, even trained scientists do not have a fundamental understanding of everything they see or do. Therefore, a worthy purpose of science in schools should be to make pupils aware of their surroundings and be able to apply know how to solve problems (Goldsworthy 2006).

2.4.2 Constructivism

What should be the nature of science education in schools? Science education should have 'a clear unambiguous world-view that gives science a purpose to seek understanding of our world as it exists' (Woolnough, cited in Poole 1995 p.10). Science is 'an attempt to discover the most general and pervasive facts about the world' (Poole 1995 p.8). These viewpoints tend to stress a worldview where science is a series of facts that all should know. The constructivist approach stresses the learning and prior knowledge of the individual and has been influenced by the individualistic learning theories of Piaget:

> Learning is a process of personal construction, and that students, given the opportunity will construct a scientifically orthodox conception of physical phenomena if they see that the scientific conception is superior to their pre-instruction conception (Posner, Strike, Hewson and Gerzog 1982 cited in Coburn 1995 p.1).

Constructivism (as opposed to the philosophical standpoint of constructionism) is widely regarded as the approach by which science is taught, (Russell and Watt 1990). Constructivism is 'the dominant approach in the last decade especially with respect to science education' (Capel, Leask and Turner 1995 p.222), a sentiment earlier echoed by Solomon (1994). Constructivism has become endorsed in National Curriculum guidance (Littledyke 1998).

The constructivist position towards education states that 'knowledge is not transmitted directly from one knower to another, but is actively built up by the learner (Driver, Asoko, Leach, Mortimer and Scott 1994, p5). Constructivism acknowledges that 'events do not just exist but are 'created by the person doing the constructing' and that 'what we experience is a dynamic interaction of our sensations, perceptions, memory of previous experiences and cognitive processes which shape our understanding of events' (Littledyke 1998 p.2). Therefore, the life experiences of each pupil and teacher shape their ideas – their constructs, and therefore their individuality. The extent to which people are similar or different depends on how similar or different their constructs are (Littledyke p.2). Gott and Johnson (1999) expressed similar sentiments, stating that 'all knowledge is a human construction and that each learner must construct his or her own understandings' (p.23).

Pupils and teachers have their own particular constructs or ideas to describe phenomena and it is through the medium of a science lesson that a pupil's prior knowledge (construct) is elicited and built upon or replaced with the scientific construct. The scientific construct should be seen to be superior to their pre-scientific conception. Scientific constructs 'are not the phenomena of nature, but constructs that are advanced by the scientific community to interpret nature' (Driver, Asoko, Leach, Mortimer and Scott 1994 p.5). They added that the role of the teacher is to help pupils to make sense of how knowledge can be 'generated and validated' (p.6). Effective learning should 'facilitate constructs which are both personally meaningful and also congruent with scientific thinking' (Littledyke 1998 p.14). This does not necessitate individualised curricula to cope with every individual's personal construct but an approach that stresses the common experiences of the class. Finding these out is important.

Learning through constructivism does not involve simply extending the knowledge of pupils about scientific phenomena. Instead, it involves developing new ways of thinking about and explaining science, and methods of supporting its knowledge claims. To do this, learners must 'engage in a process of personal construction and meaning making' (Driver, Asoko, Leach, Mortimer and Scott 1994 p.8). Learners enter the science lab with everyday constructs about scientific phenomena that evolve with them through their lives.

Scientific constructs are introduced to learners through social interactions in the lab, and each learner has to make sense of the new, scientific ways of viewing the world.

The process by which constructivism should be used in science lessons was summarised by Reiss (1993) in table 2.4:

Table 2.4 The process of constructivism

Phase	Purpose
I Orientation	Arouse interest and setting the scene
II Elicitation of ideas	To enable pupils and teachers to become aware of prior ideas
III Restructuring of ideas	To create an awareness of an alternative viewpoint – the scientific one – to: modify extend, or replace with a more scientific view
(i) Clarification and exchange	Recognise alternative ideas and critically examine own
(ii) Exposure to conflict situations	Test validity of existing ideas
(iii) Construction of new ideas	Modify, extend or replace existing ideas
(iv) Evaluation	Test validity of newly constructed ideas
IV Application of ideas	Reinforcement of constructed ideas in familiar and novel situations
V Review	Awareness of change of ideas and familiarisation with learning process to allow the pupils to reflect on the extent to which their ideas have changed

Driver and Bell (1986) listed a number of features from a constructivist viewpoint that can impact on learning through science lessons:

- Learners are purposeful and responsible for their own learning. They bring their prior concepts to the learning situation.
  -This highlights ideas of active learning and highlights the elicitation stage in Reiss's (1993) table.
- Learning is an active process on the part of the learner. It involves the construction of meaning and often takes place through interpersonal negotiation.
  - The concept of discussion in the Restructuring of ideas section of the table is raised and active learning again is stressed.
- Knowledge is not 'out there' but is personally and socially constructed. It can be evaluated by the individual in terms of the extent to which it fits with their experience and is coherent with other aspects of their knowledge.
- Teachers bring their own prior conceptions to learning situations in terms of their subject knowledge and views.
  - These fit in with the idea of individuality being related to an individual's constructs.
- The curriculum is a programme of learning tasks, material and resources from which pupils construct their knowledge.

The National Curriculum in 1998 proposed that children's ideas would change as their experience widened. There is an essential role for the teacher as enabler in this process: the teacher may interact with the pupil, raise questions, build in appropriate challenges and experiences and offer new ways of thinking. So, some idea of constructivism is embedded in the National Curriculum.

The framework of Reiss (1993) and the recommendations of Driver and Bell (1986) can influence classroom interactions. Capel et al. (1995, pp.222-3) considered how constructivism affects the role of the teacher:

- To encourage pupils to be involved and own the purpose of the lesson or task
- If pupils are to take responsibility for their learning, to design learning experiences that allow pupils to investigate processes and outcomes;
- Allowing and valuing pupils' own descriptions and hypotheses of what has taken place or assumed learnt.

Therefore, as a teacher involved in teaching theories or practical skills, the role is one of a facilitator of learning: to allow pupils to enquire, question and to achieve discoveries in an active way.

The practice of constructivism in science education was commented on by Poole (1995), who stated that it is 'stressing active, rather than rote learning, using dialogue and argument' (p.45). Active learning occurs where 'the pupil is an active partner throughout the activity' (Capel et al. 1995 p.229) and where a task 'has clear purpose and is relevant to them' (Capel et al. 1995 p.230). According to these criteria, a good piece of coursework should have relevance to pupils and build upon their knowledge with new constructs. Taber (Learning doctors 2006) wrote of how through constructivism a key concern is to identify features of student learning that can inform science teaching.

Neurophysiological evidence supports the ideas of constructivism. Consciousness is interactive with the brain tuning the ears and eyes to interpret data. Information is selected by the brain dependent on previous life experiences. Therefore, an individual's view of the world is based on their learned constructs; each person does not see the same world (Littledyke 1998).

Constructivism has critics such as Reiss (1993), who commented on the assumption 'that pupils need their ideas to be replaced with more scientific ones' (p.39), which may negate any previous constructs of theirs and give them a negative impression of their ideas. He writes of a philosophy where pupils come to science with constructs 'that have so far served them well' (p.39), and that a science lesson should show why their thinking often works and to allow pupils who wish to develop their thinking to do so by pursuing it into new areas, not by proving it wrong. An example is cited whereby pupils think of a correct concept – gravitational potential energy increasing with distance above the Earth's surface. By using the word gravity, however, instead of gravitational potential energy their understanding is deemed wrong (p.40). Learners may not take in a scientific construct because it does not agree with their existing conceptual frameworks (Taber, Learning doctors 2006). He suggested a pragmatic approach in planning for learning; to match teaching to student knowledge and to be aware of problems including that of conceptual frameworks. Telling the pupils they are correct and 'tweaking' the semantics of their idea may allow pupils to move on in their understanding. However, this does seem rather like the Restructuring of Ideas stage of a constructivist science lesson where existing ideas are modified or extended. Cobern (1995) considered the assumption implicit in constructivism – that scientific concepts are superior to any other ideas that make sense of the world. All concepts are judged by the values of science, something Feyerabend (1975) and Medawar (1982) have discussed and criticised as prioritising science constructs over socially constructed ideas.

However, the point of constructivism was being missed. According to Gott and Johnson (1999); 'the focus of attention needs to be on issues of content' (p.23). Most constructivism they claimed was concerned with teaching methods. Improving the teaching and learning environment would involve a move away from 'progression in complex recall' (p.26) which they claim was inherent in the (pre-applied / science 2006) curriculum. Instead there would be a reduction in curriculum content but what is taught should be in more detail covering substantive and procedural content. The detail of how it is taught should be left to individual teachers as 'the kind of autonomy that should attract people into science teaching' (Gott and Johnson 1999 p.27). The science 2006 curriculum does have a reduced 'core' of science that pupils must learn but it is backed with the option of additional modules. It also has a reduced content: one page worth compared with ten in the old 1999 specification (Monk 2006). Sc1 remains as a single page.

Science, as defined by the Heinemann English Dictionary (1982), is 'a branch of knowledge or study, such as chemistry or botany, concerned with the investigation of natural or physical substances, facts, laws etc' (p.969). This definition places an emphasis on investigation. Constructivism in teaching, according to Reiss (1993), is concerned with replacing or modifying existing ideas based on new scientific constructs. Therefore, a constructivist science education could be criticised by students accepting that their ideas are wrong and that the 'facts' taught by the teacher are right, rather than challenging existing ideas in the best scientific tradition, as Cobern (1995) pointed out. This is despite the constructivist viewpoint that all knowledge is temporary and based on the present limitations of our understanding (Henson and Eller 1999) and that it can therefore be changed and new constructs formed.

Constructivism is embedded in the National Curriculum (Littledyke 1998), and resonates very strongly with assessment for learning (section 2.5.4).Therefore, despite criticism from some quarters, constructivism continues to be the dominant theory behind science education.

2.4.3 Positivism

A philosophy with a different way of looking at the world and questioning it, which can have implications for teaching and learning, is positivism. Positivism has had a great influence on Western thinking (Littledyke 1998). A positivist views that 'truths exist objectively and they can be known through objective reason' (Littledyke 1998 p.1). Medawar (1982) referred to positivism as 'scientism' and defines 'the belief that science knows or will soon know all the answers' (p.34). A positivist uses observation and enquiry to ascertain these truths and relegates emotion in favour of the 'objective' truth. Unlike constructivists, positivists view events as occurring independently of observers and that based on the assumption that we hold the same perceptions of independent realities we can communicate them with each other. Differences in views are tagged as 'distorted realities' although some people may share such views (Poole 1995, Littledyke 1998).

Positivism has been a dominant influence on science:

> 'From the time of the Enlightenment until early in the 20th century, the notion of positivism, culminating in logical positivism, underpinned not only the understanding of science, but also its centrality in the generation of knowledge itself. 'There was a belief that 'science both could and would tell us all that we wanted to know' (McAteer 1998 p.1).

The scientific advances of the 20th century changed this belief. McAteer (1998) wrote of how Einstein's theories challenged the 'facts' of the time which were in many cases over simplifications or simply incorrect.

Positivism through the behaviourist paradigm dominated science teaching for most of the last century until the advent of constructivism. The job of the teacher was 'to help students learn about the real world' and to 'interpret events for them' (Jonassen 1991 p.28). Scientific ideas were passed on from the teacher to students as a series of true objective facts for them to remember (Glynn & Duit 1995). There is no mention of discussion or discovery in this form of teaching. Positivist teaching has not totally been replaced by a more interactive constructivist approach. The late 20th century National Curriculum was based on complex recall (Gott and Johnson 1999). Therefore, pupils had no choice but to rote learn content. This is despite the work of McLaughlin and Jackson (1999) who questioned pupils, finding that they found rote learning strategies least conducive to their education, and Littledyke's (1999) assertion that constructivism was endorsed in the 1989 NC non-statutory guidance. The 'positivistic faith' was accepted by very few lay people outside of science, according to Cobern (1995). Davies, McCarthy, Shaw and Sidani-Tabaa (1993) wrote of how positivist ideas dominated assessment in the National Curriculum and thus inhibited a constructivist approach.

2.4.4 Comparisons between constructivism and positivism

In comparing positivism and constructivism in science education it is important to define science as a 'subject preoccupied with the pursuit of knowledge about the world' (Littledyke 1998 p.4). The positivist approach was criticised by Medawar (1982), saying it has 'the corrupting smugness of any system of opinions, which contains its own antidote to disbelief' (p.60). A positivist view of science education is that it must teach the objective truths uncovered through empirical testing. A constructivist, in comparison, sees science as a method of testing ideas and theories of natural phenomena, to build on existing knowledge but to not accept new ideas without criticism, and social discourse. There is, therefore, more room for pupils' views to be considered in a constructivist approach. What the learner knows can contribute and be added to in such teaching. Teachers do not act as dictators passing down rhetorical knowledge; their role is changed to that of a facilitator. New ideas can be tested and discussed in the science laboratory. Pupils have more responsibility for their learning and their motivation is said to be higher than in positivist based learning (Lord 1997). Crucially, pupils are *active* in constructing their learning in constructivist teaching approaches but are passive recipients of knowledge in positivist education. Positivism also assumes there is an independent reality which can be objectively observed by all researchers. Evidence from disciplines such as psychology and neurophysiology indicate that the brain has more neural connections running from it to the ears and eyes than the other way round (Littledyke 1998); our brains influence what information we receive based on past experiences and tune our senses accordingly.

Positivist based teaching also espouses exam grades and achievement as rewards rather than encouraging the learner to take the responsibility for learning. The current science curriculum is essentially exam result driven and focuses on facts, according to Fox (2006).

Researchers such as Lord (1997), Littledyke (1998), Glynn and Duit (1995) and McLaughlin and Jackson (1999) emphasise the benefits of constructivist learning, finding subject knowledge, interest and in-depth understanding to be far greater amongst constructively taught pupils. For these reasons constructivism continues to be a dominant force in science teaching at least from the viewpoint of researchers and science educators at university level.

Positivist teaching still exists despite the research to discredit it and the viewpoints of pupils who learn through it (Gott and Johnson 1999). Education as a whole is still influenced by positivism. The prescribed nature of what children should learn in science through the National Curriculum has its roots thus. Littledyke (1998) describes positivist teaching approaches, which assume that:

> The mind of a child is a *tabula rasa* on which the function of education is to inscribe the truths and features of the world. According to these premises the function of teaching is to devise ways of ensuring that children learn what has been prescribed and assessment procedures will verify the effectiveness of the process (p.8).

This sums up the ways in which some teachers work: how can they get pupils to show, by written exam questions or by pieces of coursework, that they have met the prescribed 'truths'.

2.4.5 Active learning through science

Active learning is a part of Vygotsky's and Piaget's learning theories and of constructivist education. Active learning 'has to be done by them (the pupils), it cannot be done for them' (Black and Harrison 2004 p.4). It is a concept whereby work has individual importance to each pupil and their findings, results, conclusions and ideas are of value to them; 'a sense of ownership and personal involvement is the key to successful learning' (Capel, Leask and Turner 1995 p.229). These ideas were previously highlighted by Tytler (1992) and Woolnough 1994). The Offices for Standards in Education (Ofsted) (2004) in their report on science in secondary schools wrote of the 'benefits of making science relevant to pupils and of engaging them actively in learning'.

Types of written work in science were researched by Woolnough, McLaughlin and Jackson (1999). They analysed dictation of notes, writing an experimental procedure, and writing an explanation, and their effectiveness in terms of pupil learning and enjoyment of science, asking three classes of 13 year old pupils to rate the different types of writing on a scale of one – five, with five being the most positive score. They found that pupils were most positive towards drawing diagrams, and concept cartoons, and most negative towards copying notes from a lecture. They also concluded that where pupils take responsibility for their learning, their learning is effective. Their research was based on a small sample of pupils, and did not give the exact number of pupils who took part. The AQA Applied Science 2006 specification (AQA 2004a) wrote of the opportunities within it for pupils to improve their own learning. Ofsted (2006b) states that 'It is the first substantially different course since the implementation of National Curriculum science' (p.8). In applied courses, the work pupils do in class is to a large extent a part of their assessment portfolio of a series of experiments covering various scientific topics. By doing these, having them marked, and improving on their grades pupils are completing their GCSE science. The motivation for pupils undertaking this activity could be having their two applied science GCSEs 'in the bag' and not waiting for or worrying over exams at the end of year 11. Technically, many pupils can go into the applied Science examination in year 11 knowing they have virtually passed the course on the strength of their coursework already. This idea of changing and improving coursework polarised the views of teachers, where 'a bare majority' allowed pupils to improve their work and 'a bare minority' did not (Nott and Wellington 1999 p.14).

The implementation of active learning in applied science was discussed by Ofsted (2004). They described the atmosphere in some applied science lessons as being closer to that of post 16 lessons in terms of the 'mature ambience' of the pupils. The Learning and Skills Council Skills and Education Network website (2006) made a point of urging teachers to 'make use of a wide range of active learning strategies including strategies for independent learning, investigation and research, presentations and discussions' (p.8).

Positivist rote learning, 'when pupils are required to listen to the teacher' (Capel, Leask and Turner 1995, p.231), could include teaching pupils the 'facts' of science they must use in their assignments and in examinations plays its part in getting pupils through the rigours of GCSE science. Pupil attitudes to rote learning were questioned by Woolnough, McLaughlin and Jackson (1999). They found that pupils thought dictating notes and listening to lectures were not enjoyable and were ineffective for their learning. Ideally, applied science with its emphasis on practical coursework should involve more finding out and less of the recall based on factual knowledge. Where pupils write their scientific thoughts in their own words, it is perceived by them as better for their learning and more enjoyable (Woolnough et al. 1999). Perhaps developing discovery learning, in which students use a structured framework to arrive at a pre determined conclusion (Capel, Leask and Turner 1995) could be desirable in practical coursework assignments. Previously, Driver (1983) had argued that rote learning approaches discouraged pupils from thinking and finding their own conclusions. Guided learning could lead to differentiation by outcome, as tasks can allow pupils to reach different end points and conclusions according to ability (Capel Leask and Turner 1995).

2.4.6 What motivates learners?

Teachers and pupils alike spoke frequently of the importance of student motivation, believing that increased motivation leads to better subject understanding, according to research by Cimer (2004). In a survey carried out with approximately 2,500 11-16 year old boys and girls in 1996-7, Ross and Kamba (1997) concluded that pupils in secondary schools showed less interest in scientific subjects, in particular the physical sciences, than in technology, PE English, mathematics or art. Pupils were asked to plan their next ten lessons, and a table of the most popular choices was constructed. Some pupils found the sciences difficult and uninteresting, and a conclusion was that subjects that offered the least scope for creativity, were least regarded by students. They did not state from where this evidence came, as the study was based on pupils ranking subjects, rather than discussing them. Research about subject choice was surveyed by Ofsted (2000). They found that science was often identified as a favourite and a least favourite subject of pupils. They also found that pupils' views on science became more negative as they progressed through KS3 (page xi). This could be partly due to the images that pupils have of science and scientists (Matthews and Davies 1999). They claim that the stereotypical image of a balding male decked out in a white coat weighs heavy in many pupils' minds. This would agree with studies conducted by Matthews and Davies (1999) with primary children. The key to getting pupils to obtain a good grasp of scientific concepts is that they must understand the nature of science as constantly changing and involved in historical flux (Irwin 2000). When pupils understand how science developed they can gain a greater appreciation and understanding of it.

There are many theories about what can motivate, and contribute to learning through science. In table 2.5 overleaf, I have summarised a number of them.

Table 2.5 Some motivating factors that may influence pupil learning

Concept	Explanation	Author (s)
Pupil attitudes	With declining numbers choosing to study science many factors but especially teaching has an influence on pupil conceptions and motivation.	Osborne, Simon and Collins (2003)
Teacher specialism	The interests and specialisms of science teaching staff help in relating the subject to the outside world.	Ponchaud and Adey (1999)
Teacher enthusiasm	Students in interviews seemed more positive in their learning when faced with an enthusiastic teacher who shows an interest in their personal and academic needs.	Cimer (2004)
Diagnosing learner difficulties	Diagnosing problems based on students being unable to relate teaching to their existing knowledge.	Taber (Learning doctors 2006)
Pupil esteem	Self-esteem and acceptance by peers and staff motivated learning.	Hargreaves (1982)
Making science relevant	Making science relevant should include equipping pupils with the skills required to interpret and question the evidence they see and hear around them, including spurious advertising campaigns.	Goldsworthy (2006), Fox (2006) and the House of Lords select committee (2006)
The National Curriculum	From teacher questionnaires, it was found that pupils' enjoyment of science had declined since the onset of the National Curriculum. Individual teachers bemoaned the constraints of the curriculum denying them the opportunity to teach science relevant to their pupils	Donnelly (2000)

Curiosity and mystery	Curiosity and mystery are a precursor for learning as 'the best type of intrinsic motivation'. How can this be sustained in the classroom? (Hadzigeorgiou 1999 p.45).	Hadzigeorgiou (1999)
Careers and science	As less than 10% of careers advisors had a science background they felt less secure in recommending scientific or engineering based futures for young people. This could have a negative impact on the motivation of those considering science beyond GCSE and in their attitude to GCSE science.	House of Commons select committee for Science and Technology (2000),House of Lords select committee (2006)
Mentoring and homework	There are positive effects of mentoring and after school homework and study in helping pupils with self-esteem and motivation.	Ofsted (2002)
Humour	Humour in the classroom could motivate learners and contribute to learning.	Hawkey (1998)

Through reading and analysing this swathe of research summarised in table 2.5, I believe that reasons for motivation are as individual as each pupil that steps into a science classroom. A technique that inspires some will not work with all pupils. There is no single formula that will turn all science pupils into highly motivated learners, particularly as science is a compulsory subject at GCSE level. As Driver, Asoko, Leach, Mortimer and Scott (1994) pointed out:

> Classrooms are places where individuals are actively engaged with others in attempting to understand and interpret phenomena for themselves, and where social interaction in groups is seen to provide the stimulus of differing perspectives on which individuals can reflect. The teacher's role is to provide the physical experiences and encourage reflection, (p.7).

The aims of this study include investigating how pupils learn, with particular reference to active learning. The ideas above do not essentially drive my research, as there is not one motivating factor in the classroom that will work for all pupils. However, they need to be considered, as each pupil will come into the science classroom having their own constructs, and be motivated in different ways.

2.4.7 Boys and girls and coursework

There is a widespread perception that coursework favours girls in terms of better GCSE performance (Elwood 1999). Elwood conducted an analysis into whether girls achieved better results at teacher assessed coursework than boys. Her work encompassed mathematics, English, and (pre applied / science 2006) GCSE science. She used data from the 1997 GCSE examinations from one (non-specified) examination board, and tested whether statistically significant differences occurred between boys and girls coursework scores, and between the intended and achieved weighting for the coursework and examination components of their marks.

In science, as with English and mathematics, girls generally achieved higher coursework scores than boys. The differences in mean marks were found to be significant at the 0.05 level in favour of girls. Also, there was less variation between coursework marks for girls – they were more bunched together than for boys. As a consequence of this, boys' coursework marks, being more variable, tended to have more effect on their overall grades. There were statistically significant differences between the achieved weights of boys and girls in science at the 0.01 level, with examinations having higher achieved weights for examinations for girls than boys. Thus examinations played a more important role in determining girls' final grades, and coursework could be a factor in boys' being less successful. Elwood (1999) described this as compromising the validity of such examinations, as the intended weightings of coursework and examination scores did not operate as they should. Elwood (2005) summed this up by stating that:

> the *actual* influence of coursework in contributing to girls' and boys' success is quite different to its *perceived* influence as understood by examiners, teachers and students (p.390).

Elwood's (1999) research was concerned with pre science 2006 and applied science results, and as such is an important piece of research, as it highlights real and perceived differences in coursework grades, and their influence on actual grades. There is, however, no existing research outlining the effect these new specifications have made to the significance of boys and girls coursework grades.

Table 2.6 indicates that sciences in general had a low level of gender difference in 2001 in comparison with many subject areas and indeed the only subject showing better results for boys than girls was physics.

Table 2.6 Ofsted (2004) chart of results difference based on gender in GCSE scores 2000-2001

Subjects where girls do better than boys	Average points difference	Subjects where boys do as well as girls	Average points difference
Art and Design	0.91	Combined Science – Single Award	0.24
Religious Studies	0.82	Business Studies	0.22
Spanish	0.72	Biology	0.15
Home Economics	0.72	Physical Education	0.14
Design and Technology	0.71	Chemistry	0.13
Communication Studies	0.70	Combined Science – Double Award	0.12
Other Languages	0.70	Statistics	0.11
French	0.70	Mathematics	0.05
German	0.62	Physics*	-0.15
English/English Language	0.61	* indicated better results for boys than girls.	
English Literature	0.61		
Drama	0.61		
Humanities	0.60		
Sociology	0.59		

Gender difference in GCSE science double award results was investigated by Bell (2001) by applying t-value analysis. A value of -1.5 or lower meant that the mean value for that question is higher for boys. A t-value of +1.5 or above meant the same for girls. The aim was to find out why girls performed better at biology, and boys at physics (Bell 2001). He sampled the results of 250 students and investigated Sc1-4 questions that were either concerned with data retrieval, or factual recall. Bell (2001) found that in 'questions that involve the retrieval of declarative knowledge' (p.485) boys generally achieved better results in physics questions, girls at biology. A similar conclusion was reached by the DfES (2006b), who reasoned that girls achieved more in open ended process based work, whereas boys tended to shine in memorizing rules and concepts that need to be remembered quickly. Boys' grades tended to be higher at problem solving in science, according to research in Scotland by Powney (1997). The results of Bell's (2001) study were accredited to more girls preferring the personal nature of biology, particularly human biology, and boys preferring the impersonal data of physics, without offering data to support this assertion. Instead, Bell (2001) attributed the findings to 'differences in the types of activities boys and girls prefer to engage in and the environments made available to them by parents and peers' (p.484). This in turn affects the ability of a pupil to retrieve scientific knowledge from an exam question and link it to what is asked for in the answer. Bell's (2001) study was conducted before the advent of applied science and science 2006 and consisted of one type of analysis. However, his results provide some evidence for relatively higher male achievement at physics in terms of GCSE grades, as shown in table 2.6.

The approaches to studying GCSE subjects, including science, amongst high achieving girls and boys were researched by Rogers and Hallam (2006). Their study involved 310 pupils (176 boys and 134 girls) from years 10 and 11 from two single sex schools. The schools were successful academically, with half of their pupils expected to achieve eight or more top grade GCSE results. The pupils were given a questionnaire consisting of 42 questions on a five point Likert scale, where 1 = strongly disagree, and 5 = strongly agree. After a pilot study with 65 pupils, the questionnaire was delivered to the pupils during form time.

The results of the questionnaire, published as standard deviations, indicated that, overall, boys were more positive about examinations, as they defined what they needed to learn and were able to revise in short bursts, as the DfES (2006b) also found. They were less anxious about them than girls. This was found to be statistically significant at the 0.01 level. Girls tended to be more concerned that they did not achieve their potential, and that they had too much work to cover. In terms of coursework, there were few differences and no statistically significant differences in viewpoints. This is 'contrary to suggestions that boys are less than conscientious, lack the necessary organization, and planning skills and are insufficiently motivated to do well in relation to coursework' (Rogers and Hallam 2006 p.68). Rogers and Hallam's (2006) study was concerned with pupils with above average academic achievement, and concentrated on two schools. The results may not be applicable to less academically gifted students, who may lack the study skills and motivation of the respondents to their questionnaire. Nevertheless, the results do provide evidence of the similarities, and differences of gender attitudes to coursework and exam based study.

Other studies have mentioned a lack of interest amongst some girls in science (Cowie 2005, Millar, Slawinski – Blessing and Schwartz 2006). The House of Lords select committee (2006) claimed that girls are more likely to be deterred by poor or uninspiring teachers. Girls, particularly, rejected science as soon as the chance arose (Gott and Duggan 1995). However, Ofsted (2006a) claimed that boys continued to achieve less well than girls in KS3 tests and General Certificate of Secondary Education (GCSE) results. This can be seen in the results displayed on table 2.6.

The role of examinations, and how they contribute to gender differences, in terms of summative results was researched by Elwood (2005) who argued that the notion of boys' under performance in comparison is a simplistic one that does not take into account certain factors. She pointed out how, in 2003, less low attaining boys were entered for GCSE examinations than girls. In that year, 53% of all examination absentees were boys.

Differences in male and female attitudes to science in secondary schools in the USA were researched by Millar, Slawinski – Blessing and Schwartz (2006). They distributed questionnaires to 80 high school students, aged from 16 – 18, receiving 79 responses. The questionnaire contained three parts, the first being a list of subjects to rank in order of preference. Secondly, they were asked to rank their favourite course, and why they liked it, in comparison to chemistry, and thirdly they were asked what subject they may want to take at university. In terms of ranking of courses, the results showed an overall preference for science and mathematics amongst boys, significantly more so for chemistry, and a f preference of girls for English and Spanish. For biology, there was no difference in preference. When comparing their favourite courses to chemistry, boys showed a significant preference for the physical sciences and mathematics (21 out of 39), whereas girls' preferences were spread over many subject areas, including 15 listing biology, physical sciences or mathematics. Both boys and girls noted liking the subject matter and the teacher when describing their favourite subjects. For the final part of the questionnaire, significantly more boys indicated that they would take a science subject at university. Biology proved to be the one science subject that girls found interesting, attributed to biology being a people orientated, helping science. Miller et al. (2006)

summarised that girls tended not to find science interesting or relevant to their ambitions. Their study was based on one school in the USA, and is based on the US education system. Therefore, their results can be generalised with caution, but they do provide extra evidence of gender differences associated with science education.

The House of Commons Select Committee on Science and Technology (2002) stated that 'the GCSE science curriculum failed to provide for the differing interests of boys and girls' (p.25). They cited evidence from various schools where pupils and teachers bemoaned the lack of topics particularly relevant to one of the sexes e.g. medical science and advances for girls, nuclear fission for boys. This was explained in terms of career choices, where girls were more likely to want content specific to the caring careers they may enter, such as medicine or nursing. Boys, however, showed more interest in technical careers, and learning from interest alone. Nieswandt, writing in Alsop (2000) came to similar conclusions. 'Observational sciences such as anthropology, ecology, and more recently, astronomy have historically attracted more female than male practitioners' (McAteer 1998 p.6). McAteer (1998) also argued that the science curriculum in 1998 had 'inequity and specifically, an anti-female bias in the processes and systems of science education' (p.6). She justified this by comparing how boys and girls learn from Piaget (1968). Piaget mentioned how boys were more likely to learn via systems (such as prompt sheets, working towards prescribed results and marks schemes) whereas girls take each piece of coursework on its own merits. Boys tended to dislike the writing inherent in science assignments but girls were happier to accept it, according to interview and questionnaire data compiled by Nott and Wellington (1999). Therefore, different assignments with different assessments, such as those in double award applied science unit 3 should appeal more to a female student. In the Scottish educational system girls tended to outperform boys at science coursework, and male grades were higher at problem solving in science (Powney 1997). However, the stereotype that examinations are biased against male students was dismissed by Powney (1997), who stated that Scottish higher examinations in 1993, questions 'were, overall, gender – balanced and avoided stereotyping in language and roles where males and females were portrayed' (p.2). The different treatment of boys and girls by teachers is noted by Nieswandt, writing in Alsop (2000), who asserted that teachers challenged boys more than girls in questioning sessions. Using a coding system to record teacher – student vocal interactions, Jones and Wheatley (1990) analysed over 30 science classes. They examined the data for gender differences. The results indicated that female teachers warned boys significantly more than girls, but that male teachers warned both genders with a similar frequency. Boys were subjected to significantly more behavioural warnings in physics classes than girls. In chemistry classes, both boys and girls received approximately the same number of behavioural warnings.

Peer group pressures cultivate the image of the nice quiet girl and the disruptive behaviour of boys more than girls. Therefore, boys are more likely to live up to these behaviours in order to gain support from their peers (DfES 2006b). In a report on schools attempting to teach single sex science to lower ability boys, Ofsted (2004) found negative peer group pressure to be a serious issue. They quoted some schools with a male student population of over 60% to often have an 'anti-learning or 'laddish' culture among some low attaining boys' (p.18). Some schools attempt to deal with this by focusing on providing boys with role models to promulgate the idea that being a good learner is something to be celebrated, rather than derided as 'uncool' (The National College for School Leadership 2006). The DfES (2006b) also reported on the idea of single sex teaching, finding that results had indicated there were greater levels of participation in lessons and increased confidence among both sexes. Teachers often felt that behaviour was better in single-sex groups. Pupils are almost always in favour of single-sex groupings, especially girls. However 'the effect of single sex classes in mixed sex schools is variable with some marginal gains recorded but other unsuccessful examples' (Ofsted 2006a p.5). They also point out that amongst Organization for Economic Cooperation and Development (OECD) countries the gender gap in the UK was significantly narrower than all but five nations.

However, it is only *some* boys, who have behavioural difficulties, and a lack of interest in science, and underachieve in comparison to girls (Younger and Warrington 2005). They claim that against a background of rising achievement, girls' GCSE grades increased at a higher rate than have boys' grades, but that the gap had stabilised. They also stressed that large numbers of boys have achieved excellent grades whilst maintaining peer respect.

A study based on male and female coursework attainment at university level was undertaken by Woodfield, Earl-Novell and Solomon (2005). They studied the perception of final exams favouring male learning and continuous assessment being more advantageous to female learning: 'Girls are presumed to prefer coursework and be more likely to perform better at it due to the fact that their average personality dispositions dovetail with this particular assessment mode' (p.36). Their study found that, overall, female undergraduates outperformed their male counterparts at both coursework and exam results (at first class honours degree level). They also conducted qualitative questioning, which concluded that neither sex had a preference for examination or coursework as a means of assessment. Instead a majority of both sexes preferred coursework.

Amongst Woodfield et al.'s (2005) sample were females who admitted to performing better with the pressure of an exam, and males who expressed a preference for coursework and continuous assessment – both the antithesis of the stereotypes and assumptions they were testing. Indeed, they received more positive responses for females towards exams and males towards coursework. Also, both male and female students achieved higher grades at coursework than grades at unseen examinations. They also noted a higher degree of anxiety over academic issues amongst women and many responses indicated higher work rates amongst female students. Data supported this assumption; an analysis of self reported independent work rates from 108 students showed the average female worked 17.78 hours per week and the average male worked for 13.04 hours. As this was a self-reported exercise, the 'more conscientious' (p.43) female students may be more likely to fill them in. No data about the number of respondents of each sex was printed. The more work put in by female students may be linked to a greater anxiety expressed by them towards exam and coursework studies.
The effects of removing coursework in male and female attainment in English and mathematics were considered by the QCA coursework report (QCA 2006e). Their findings were that removing coursework did not have any bearing on differing achievement in English and similar achievement in mathematics.

The wider picture of gender attitudes to science was analysed by Reid, Martin, Delaney, Cloke, Bishop and Dodsworth for the Engineering and Technology board (ETB) in 2003. Their review of research on the subject found that female and 'less educated members of the public tended to hold negative views of science and felt disengagement between their own lives and science. Science, alongside engineering and technology was perceived to be 'irrelevant, uninteresting, lacking in career opportunities, unethical and male dominated' (p.18).

2.4.8 Coursework and collusion

Coursework cheating is 'all forms of dishonesty and plagiarism' (Williams 2001 p.226). Plagiarism 'involves using other people's words and ideas as if they were one's own, without crediting the source' (Park 2004 p.291). Jones, Reid and Bartlett (2005) described collusion as 'the collaboration without official approval between two or more students (or between student[s] and another person[s]) in the presentation of work which is submitted as the work of a single student' (p.82). This section explores the role of collusion and cheating in the completion and assessment of coursework.

An investigation into cheating in higher education was undertaken by Franklyn-Stokes and Newstead (1995). They analysed a total of 128 questionnaires, concluding that the main reasons for cheating are time pressure, and a desire to increase grades. Their research was based on university students rather than those studying for GCSE. However, their research provides empirical evidence of the reasons why students cheat. Jones, Reid and Bartlett (2005) used a questionnaire to sample the views of 171 students about cheating. They reported that 43% of students did not think plagiarism would be detected. Their work was also with undergraduates, as a lot of the extant literature is, but it provides additional empirical evidence of student views.

What motivates pupils, teachers and others to cheat with coursework? When pupils complete the same task, they can copy (Jennings 1992). However, the nature of some coursework tasks, such as obtaining results, in all of the specifications of this study, encourages collaborative work. Jennings (1992) also wrote of that parental assistance can influence the quality of coursework, when it can be completed at home. Jennings (1992) was writing about mathematics coursework specifically, and did not qualify his statements with empirical evidence.

Cheating is common amongst teenagers, according to Anderman, Griesinge and Westfield (1998). They sampled 284 students aged between 11 – 14 years old in science classes, as a case study, in one American school, using questionnaires. They found a link between cheating and extrinsic goals, for example, examination results. Students who perceived that they could get a reward, such as no homework, were more likely to cheat. In total, 39% of their sample admitted to cheating. They also found no link between gender and cheating. Their results were from a case study at one school, at one time, in the USA, which highlights the issue of whether the results can be generalised. However, they do show the views of high school aged pupils who studied science.

For students, looking at their peers' essays or being given their notes did not count, to them, as cheating (Williams 2001). She sampled fifteen secondary schools in her research, interviewing 120 teachers across the subject range. She found that teachers used a range of mechanisms to minimise cheating. The first was to warn pupils of the negative consequences of being found out, whilst emphasising the need to take pride in their work. Secondly, teachers used observation. By recognising the level and style of work a pupil is capable of, a majority of teachers felt able to spot passages lifted from their peers. I know of one instance in my teaching career where coursework has been returned by a moderator because two pupils had sent in exactly the same piece, word for word. Thirdly, by reviewing three or four drafts of work, teachers were able to recognise improvements that may not be due to a pupil's sole efforts. Marker vigilance, in finding similarities between pieces of work, or unusually high standard is a 'tell tale vehicle for detecting plagiarism' (Park 2004 p.299). Finally, by discussing their work with individual pupils, teachers ascertained how they reached their level of attainment. Williams did not reveal the questions she used, or whether her interviews were conducted on a one to one basis. I would question whether teachers may have the time to review so many drafts of work, or to discuss their work with individuals. However, her results come from a range of schools and a large number of teachers and as such have validity. Williams (2001) also reviewed research conducted in the USA, where 80% of students interviewed admitted to some form of cheating. The pre 2006 science curriculum placed undue emphasis on quantitative data. This led to 'pupils inventing discrepant data points so as to be able to critique them and thereby score higher grades in an examination' (Monk 2006 p.120).

Educators need to place more emphasis on a concept of 'a culture of scholarship' (Williams 2001 p.237) where sharing results and ideas are seen as distinct from collusion and copying, which is not acceptable. She wrote of how some teachers tried to instil these values in their pupils, but gave no ideas as to how they can be instilled across secondary education. Informing students of acceptable behaviour in completing their work was described as more advisable than severe punishment (Franklyn-Stokes and Newstead 1995). They also concluded that the fear of punishment was a major reason why students do not cheat.

Issues relating to coursework assessment at GCSE level were considered by the QCA coursework report (2006g). Help and advice from teachers and parents were highlighted as being poorly defined and open to interpretation. Different schools use techniques such as writing frames and templates whereas other centres regard these as malpractice. They reported on a telephone poll where 63% of a sample of 400 parents admitted to helping their pupils with GCSE coursework in some way. Coursework marks can be collected by different teachers in a centre, and they are then moderated by the exam board. According to the QCA (2006g), one quarter of questionnaire respondents admitted that their grades had been altered, but only a third of them had been improved. Many centres appoint a teacher or head of department to standardise the coursework for that centre. The work is then sent to the exam board.

2.4.9 Summary

In science education, there is an emphasis on how children learn, as well as what they learn, and this has influenced pedagogy. The learning theories of behaviourism and cognitivism, and the work of Piaget and Vygotsky have aided the development of constructivism, the prevalent approach to science teaching and learning. Constructivism emphasises the personal nature of learning and acknowledges that every learner has their own ideas – constructs that they bring to the classroom to be replaced by more scientific ones. Active learning, where the learning is done by, and for the pupil can lead to more effective learning of scientific concepts. There is a range of theories as to what motivates learners. Positivism, where scientific 'facts' were passed from teacher to student was the dominant approach before constructivism, and can still be seen in the classroom. I encountered little research analysing active learning and constructivism through coursework and examination lessons in GCSE science, which has sharpened my research focus to research this aspect of science pedagogy.

Coursework was said to favour girls (Elwood 1999). However there proved to be greater variation in boys' coursework grades, and more influence on their overall performance in Elwood's (1999) study. Other researchers have found boys to be more in favour of exams and less anxious about them. At university level, girls outperform boys at coursework and exams. Despite a lot of literature concerning boys and girls attainment, and in my personal experience, a lot of non empirical hearsay about coursework supposedly favouring girls, I have found a gap in the literature concerning whether there are any actual differences in boys' and girls' attainment in coursework and examinations across the applied and science 2006 GCSE specifications. This is a focus for this research study.

Cheating can be related to extrinsic goals such as exam grades. Help from teachers is said to be poorly defined and open to interpretation (QCA 2006g). The future of coursework based assessment was commented on by Williams (2001), who stated that 'As technology develops further, as more press reports raise fear about 'essays available on the internet', as computers become ever more sophisticated, there will be no choice for the education system other than to retreat into traditional methods based on terminal supervised exams, or to open to discussion the whole area of the creative use of assessment' (p.238). The science 2006 approach of coursework assessments completed in examination conditions, once the collection of results has been completed, indicates a retreat towards supervised, but not terminal exams. I believe that pupils should be given the opportunity to complete coursework outside of examination conditions, where they can assess and improve their work in a less stressful environment. For this thesis, the overarching themes derived from this section are the effectiveness of different types of science GCSE coursework, in terms of pupil learning and overall examination grades (including differences between boys and girls) and pupil and teacher attitudes towards GCSE science coursework.

Part Four: Assessment

This section is concerned with assessing science coursework. I have explored what skills are assessed in modular, applied and science 2006 coursework. I have researched the definitions and roles of formative and summative assessment, alongside assessment for learning.

2.5.1 What is assessment by coursework and exam for?

Both examinations and coursework exist as tools for assessment. Assessment is a central purpose of schools and of learning. Since the inception of the National Curriculum 'the work of secondary science teachers has become increasingly directed towards meeting the demands of assessment' (Jenkins 2000 p.334).

Within a constructivist framework assessment is essential in ascertaining to what extent pupils have been challenged and extended (Littledyke 1998). For a positivist approach assessment checks to what extent pupils have achieved what the curriculum has set them to learn, as (Davies, McCarthy, Shaw and Sidani-Tabaa 1993).

Brooks and Tough (2006) outlined a number of factors that they considered the purpose of the entire system of assessment in schools in England and Wales:

1) 'Formative assessment is ongoing assessment during teaching that facilitates the learning of pupils. Formative assessment should be used by pupils and their teachers to ascertain gaps in their knowledge that can be worked on and improved as well as for rewarding knowledge' (Brooks and Tough 2006, p.4).

2) 'Summative assessment assesses and accredits the knowledge and skills of pupils at certain stages through their academic careers, and takes place at the end of programmes of study, for example GCSE examinations at age 15-16. Such national tests should be a valid and fair measure of performance that can be trusted by pupils, teachers, parents and employers' (Brooks and Tough 2006, p.4).

Three products desired of assessment were described by Russell (1996): the public accountability of teachers and schools, more important since the advent of league tables; assistance to students, which can be done through assessment for learning; and certification through exam passes. Both formative and summative assessments can be used to achieve these goals. Teachers can use summative assessment as a measure of their performance and I have seen it used as part of performance management, with which teachers can progress along the career ladder. Summative assessment is essentially test and exam result based, and is used at the end of teaching units to check what has been learned. Writing about the role of assessment in the National Curriculum, Jenkins (2000) pointed out that 'the emphasis, now dominant in English secondary education is on examination results' (p.332).

The use of ongoing assessment in planning at key stages three and four were criticised by Ofsted's 2004 report into science in secondary schools. According to them, only half of the schools they sampled were competent at using ongoing formative assessment. The use of formative means of improvement can be important for many pupils to understand how to improve their work as both a piece of assessment for learning and a Popperian way of learning by discovering and eliminating mistakes.

2.5.2 What is assessed in science coursework?

2.5.2.1 Modular science

The AQA Science: Double Award Specification A (Modular) (AQA 2004b), which was phased out by the end of the 2006/7 academic year described the investigative skills needed at key stage four (p.14) as to be able to:

- Devise and plan investigations, drawing on scientific knowledge and understanding in selecting appropriate strategies
- Demonstrate appropriate investigative methods, including safe and skilful practical techniques, obtaining data which are sufficient and of appropriate precision, recording these methodically
- Interpret data to draw conclusions which are consistent with the evidence, using scientific knowledge and understanding, whenever possible, in explaining their findings
- Evaluate data and methods

These were assessed as four marking areas: Planning – the skills of writing an aim and a prediction, backing it up with scientific knowledge, writing a method and devising a fair test, Obtaining evidence – including constructing tables of results, taking repeats of test, calculating averages, Analysing and considering evidence – graphing results and interpreting them with scientific knowledge and relating them to a prediction, Evaluating evidence – commenting on the quality and validity of evidence, recognising anomalous results and considering improvements to ensure more accurate results were the experiment to be repeated (AQA 2004b p.137).

Thus, modular science coursework assessed the ability of pupils to plan and predict an experimental outcome, observe phenomena and analyse and evaluate what they have observed with a view to repeating the testing to obtain more reliable results, i.e. results which will remain constant over time through different experiments, and can be predicted based on the equipment used (Black 2004, AQA 2009). AQA (2009) define validity, in terms of GCSE science, as results produced with only one variable changed during the test, the independent variable. Every other factor is kept constant, and there is no researcher bias. Pupils were learning, and being assessed, on a series of skills, including combining substantive scientific knowledge and procedural understanding of experimental design and usage, to develop higher order investigative skills (Gott and Roberts 2006).

2.5.2.2: Applied science

Applied science courses have used a range of marking criteria for the different coursework components. A generic mark scheme has been used for six of the seven pieces in unit 1 – developing scientific skills, and it is this I have discussed here.

The AQA applied science double award 2007 specification was marked in four areas: Carrying out a risk assessment and using equipment safely, Obtaining and recording results, Manipulate data to explain findings, Evaluate the strengths and weaknesses of the work (AQA 2005a).

This shows a slight shift away from the planning of theoretical method based science towards exploring science as it is practised in the workplace. This was evident in area A where a risk assessment, equipment list and the teacher's assessment of practical skills are utilised. This last part is taken further in science 2006. The rest of the mark scheme concentrated on similar things to modular science with obtaining results, concluding and evaluating to get better results all marked as points B, C and D.

2.5.2.3: Science 2006

Science 2006 utilised a more controlled form of coursework than modular or applied science. Questions concerning the control, dependant and independent variables, and the validity and reliability of their test are set on a set of results a candidate obtains from an investigation. A second set of questions is then set on some similar data supplied by the exam board (AQA 2005b).

In addition to this the PSA or practical skills assessment grades pupils on their ability to use apparatus. There are three levels, which are continually assessed by the teachers with a maximum mark of six:

- Level 2: Practical work conducted safely but not methodically and with errors and can use equipment with help
- Level 4: Practical work is conducted in a reasonably organised way with no assistance
- Level 6: Practical work is conducted safely and in a well organised manner with skill in a demanding context

(From AQA 2005b p.72)

The only skills remaining from the modular science specification that have been employed are those of analysis and the collection of data to agree or disagree with a hypothesis. Even this has been reduced, as some of the results are supplied. There is no setting of a hypothesis and little writing up of a whole experiment. It has been replaced by grading the manual skills required to do practical work: the procedural ideas espoused by Gott and Duggan (2006). It can be considered that by allowing pupils to question the validity and reliability of their results, they can question the methods used in scientific result gathering, thus developing their procedural understanding (Gott and Roberts 2006).

2.5.3 Feedback

Feedback to students was defined as 'information that gives the learner the opportunity to see how well they are doing or have done and what they might do next to enhance their performance and knowledge' (Cowie 2005 p.200).

A study into the role of feedback in secondary education assessment was conducted by Carnell, in Askew (2000). For this, she interviewed 14 students in groups of two or three, from years seven – 11 in a secondary school, and analysed the results. She firstly asked the pupils to describe an instance where someone helped them to learn. She found that in every instance, the answer related to verbal feedback. Teacher to student feedback was characterised by one way dialogue from the teacher to the student, concerning how to improve the work, or to identify mistakes, and always took place in the classroom. These were split into four categories:

- Clarifying goals
- Giving work a sense of purpose

- Identifying mistakes
- Providing advice

Pupils were more likely to engage in such dialogue with teachers they knew and trusted, a finding also reported by Cowie (2005). Pupils were also concerned that teachers may take offence from what they say, according to Carnell (in Askew 2000). She points out how:

> The language used by the young people illustrates a particular form of communication, for example, 'the teacher *gives* suggestions', '*tells* you your mistakes', '*makes* us learn'. This form of feedback represents a reception view of learning in which teacher 'instructs' their pupils (p.56).

In this way, feedback, according to Carnell, in Askew (2000), can contribute to formative assessment, with the student a compliant beneficiary of change. It was previously found that feedback between teacher and pupil involved the teacher asking questions, and often manipulated the conversation in order for the pupil to give an expected answer. This, they claimed, resulted in pupils working out, or guessing, what the teacher wanted them to hear, rather than thinking out the answer for themselves (Black and Williams 1998).

The value of using tests in class or as homework for feedback was discussed by Black and Williams (1998). Where marks are only given, the feedback is not benefit, as pupils do not know where they can improve. They claimed, without supplying evidence, that feedback can improve learning, when it gives pupils specific guidance on their strengths and weaknesses, and does not have overall marks. Pupils must be given the opportunity to work on their weaknesses.

2.5.4 Assessment for learning

The term assessment for learning was used by Black and Williams (1998) to describe 'activities undertaken by teachers - and by their students in assessing themselves – that provide information to be used as feedback to modify teaching and learning activities' (p.141). They stated that it is the pupil who should be the main user of assessment information that has been elicited in order to improve learning. Assessment for learning should provide formative feedback to students so that students know how they can improve their work (Moore 2005).

Formative assessment in schools, and whether it could lead to an improvement in test scores had previously been studied by Fuchs and Fuchs (1986). They analysed a series of research articles whereby a control group had been used to test whether formative assessment had any effect on the academic performance of schoolchildren at all ages. They found 21 suitable studies, and a total of 3,835 participants, amongst whom, 83% had learning difficulties 98% of those mildly so. By applying statistical analyses to the results, they found that the use of systematic formative assessment, with pupils with mild learning difficulties, lead to significantly increased school achievement. Although their tests were based on pupils with learning difficulties, the results do show the affect, on performance in tests, of regular formative assessment techniques. Their results were used by Black and Williams (1998) to justify the use of formative assessment to raise standards in the classroom, in a strategy that became known as assessment for learning.

The role of self assessment by students was researched by McDonald and Bould (2003). They theorised that 'it is not sufficient for feedback on learning to be solely the province of teachers' (p.210). As Cowie (2005) later pointed out 'active student self assessment in line with teacher goals and criteria is the ultimate goal of formative assessment (p.200). McDonald and Bould's (2003) research encompassed ten schools in Barbados. Two classes of 30-40 students were chosen from each school. 256 students in total were given training in self assessment, and a control group of 259 from a further ten classes at the same schools, were used as control groups. The experimental group were given formal training on how to validate, apply and evaluate assessment criteria to their work.

The findings of McDonald and Bould (2003) indicate a positive response to students developing their own assessment. With an 88% response rate, the feeling of students was that self assessment allowed them to be 'analytical (90%), critical (85%), independent (98%), empowered (82%) and to improve their study habits (98%) (p.215). Using t-test analysis (section 3.6), their study revealed statistically significantly higher examination scores in all subject areas at the 0.01 level for the experimental group than the control group. Therefore, the study has pinpointed how successful self assessment can be in terms of improving summative results. However, the study was carried out in a different setting to the UK education system, on an island of a quarter of a million people, where significant training was offered to those pupils taking part in self assessment. The question remains as to whether it would be feasible to train much larger cohorts of students to self assess their work, and whether the gains described by McDonald and Bould (2003) would be sustainable with far larger numbers of students over a longer time period.

The concept of whether assessment for learning by teachers led to an improvement in examination and test results was researched by William, Lee, Harrison and Black (2004). They commented on the difficulty of implementing AfL since 'the introduction of high – stakes, state – mandated testing, such as now exists in England' (p.50). Their research was based on six schools in England. Two science, and two mathematics teachers from each school undertook training into using AfL effectively in the classroom, and developed action plans, including developing peer – assessment, sharing criteria with learners, and comment only marking. The teachers were observed each half term and it was noted that adopting AfL practices took time, and that changes in practice occurred towards the end of the project. The results of the intervention, in the form of GCSE and test grades, were compared with comparison classes; those that had not been taught by teachers using Afl practices, or other sets taught by the teachers involved in the research, or parallel classes taught by those teachers in previous years. Therefore the comparison data shows variations, and is difficult to interpret, and is applicable to the six schools used in the research, rather than more broadly to schools in England. The results did show a trend that the more 'expert' the teacher, the greater the effect of AfL in terms of pupil test results. There was an overall positive result in terms of GCSE examination results.

The perceptions of students towards assessment for learning were investigated by Cowie (2005) in New Zealand schools. She theorised that learning science is not only about methods and facts; the classroom practices to which students become accustomed to, affect how they see, and learn science. Her study firstly encompassed interviewing 31 students, to evaluate their views about formative assessment. The second part of the research involved observing 10 classes through a unit of science study (10-17 lessons). 75 students were interviewed during this phase. All of the students were aged from 11 – 15. The interview and observation data was then pooled to evaluate student perceptions of formative assessment. Students viewed one to one help from a teacher as being beneficial to their learning, but they were worried that by having their books and ideas checked by the teacher, they would be proved wrong in what they were doing. This idea of wrongness extended to students asking questions. 40 students chose to deliberately not ask questions, in case teachers would not respond positively, or would disregard their ideas. However, students were positive about working as members of groups, to assess each others' ideas or work, and that many formatively assessed their ideas against those of the teacher during lessons. Students also have perceptions of who, in their classes, are good or bad at science. The idea of being perceived as bad at science prevented many students from answering questions in class. Pupils want feedback for two reasons; as suggestions to help them to think and learn, and as help to complete tasks to improve their performance. Lastly, students identified respect and trust, between teacher and pupils, as essential to effective formative assessment. This involved teachers giving feedback in the form of suggestions, in language students would understand and a willingness to re-explain ideas to them. Although based in New Zealand, and not giving exact numbers of students who perceived the different themes, Cowie's (2005) study provides an original insight into the views of students towards assessment for learning.

The QCA website AfL section (2006d) offered a number of points that they claim characterise assessment for learning:

- sharing learning goals with pupils
- helping pupils know and recognise the standards to aim for
- providing feedback that helps pupils to identify how to improve
- believing that every pupil can improve in comparison with previous achievements
- both the teacher and pupils reviewing and reflecting on pupils' performance and progress
- pupils learning self-assessment techniques to discover areas they need to improve

The concepts of pupils improving on what they know / have done and reflecting on progress relates to the concept of restructuring of ideas in constructivism. The definition of pupil self assessment relates to pupils being active partners in learning. Students can do this by becoming engaged in self and peer assessment of class work and coursework (Black and Harrison 2001). They claimed that 'students learn from taking the role of teachers and examiners of others' (p.45). Sharing criteria for assessment with students also motivates them (Black and Williams 1998, Harlen 2004) and boosts teacher motivation. Black and Harrison (2001) linked their work to constructivism, stating that 'constructivist principles stress the importance of stating where the students are. What is added here is the need for students to be aware of where they are in the light of some understanding of their work' (p.44). So, giving students a role in assessing theirs and each other's learning can still be a constructivist mode of education. The same authors pointed out how teachers viewed active learning as transferring responsibility to pupils, which some were uncomfortable with. Perhaps with the implementation of AfL in the last few years teachers have become more comfortable with it since 2001, as Harlen's (2004) work suggested.

Learning outcomes should be set at the start of each lesson and be referred to during it, rather than referring to extrinsic goals such as exam grades, which are said to encourage shallow learning (Harlen 2004). Teachers considered assessment practices as likely to have a positive impact on their teaching. This is provided they find them of value in helping them to learn more about their students and to develop their understanding of curriculum goals (Harlen 2004). Jones, Gott and Jarman's (2000) research shows teachers in that year did not think that pupils achieved a great deal of understanding from their coursework.

A positive response by older pupils to AfL was revealed by Harlen's (2004) literature review. However, pupils sometimes need help in recognising what they need to aim for to achieve good work. Non-judgemental feedback was found to be particularly motivating for them. The Assessment and Learning Research Synthesis Group (2006) review of AfL concluded that summative assessment produced positive responses from pupils; they felt it motivating and gave them the chance to learn during the assessment process. Pupils did however feel that they needed more guidance in letting them know what is expected of them in terms of assessment.

AQA (2004a) placed a central aim of their applied science specification of empowering candidates to take charge of their own learning and development. Gadd (2004) commented that applied science pupils should be 'encouraged to develop skills associated with using science with managing themselves, relationships, time and resources and communicating effectively' (p.77). Where pupils can see their lesson objectives and the reasons for their learning they can become, as stated by Black and Harrison (2004) 'more committed and effective learners' (p.4). Murray (2007) claimed that when compared with Zambian pupils, 'UK learners are confident, active learners' (p.123). This highlights progress towards achieving AfL objectives. As Harlen (2004) wrote, the criteria for successful completion of pieces of science may not allow great scope for teachers to pursue and assess their own goals, as their goals will invariably be linked to external criteria for the completion of coursework.

In an article calling for a return to 'assessment for teaching', Taber (2006) considered the benefits of AfL. He asserted that 'asking students to mark their own work is only straightforward when the answers, and the criteria for assessing them, are relatively trivial' (p.484). However, some of the criteria for assessing a piece of coursework, particularly in applied science where there are different criteria for different pieces, are anything but straightforward. Taking AfL to its limits would assume that students who assess each other's work have pedagogic knowledge enough to recognise misconceptions and suggest improvements. Taber (2006) felt that AfL should be renamed 'assessment that facilitates learning by informing teaching' (p.485). Teachers should be selective in recognising where they should transfer responsibility, share it with pupils or control the marking. The diagnostic skills of a trained experienced teacher cannot be replicated in pupils each with their own constructs and ideas about science.

2.5.5 Summary

There is a range of criteria through which the different coursework specifications are assessed. Assessment can be summative, in terms of examination, coursework and test results. It can be used to judge the performance of schools and teachers. Formative assessment can be used to improve work and ascertain pupil gaps in knowledge. Feedback from teacher to student can be used to clarify goals and give advice, and help pupils to improve their work. Assessment for learning, which borrows from constructivism, involves assessment from the teacher and the pupil to provide feedback to modify and improve work, with the pupil the main user of the information. Researchers have described how assessment for learning may improve attainment. I believe that effective assessment for learning, where pupils know clearly how to assess and improve their work, and where they can see their grade improve, can motivate pupils to work hard and increase their summative GCSE grade.
The literature, although is bereft of research detailing the perceptions and attitudes of students and teachers to using feedback, and assessment for learning to improve coursework. Nor are there any studies of whether there are significant variations between the attainment of pupils, across the specifications, in summative coursework and examination grades. This is an area that has influenced the development of my research.

2.6 Overall summary of the Literature Review

The purpose of this chapter has been to draw together strands of the extant literature that forms the backdrop to my research. The themes of curriculum, teaching, learning and assessment have provided a theoretical setting to frame and re-focus on the intention of the research study and against which to analyse and interpret the data and findings of this research.

The concept of an investigation is varied and is becoming more so with the advent of new science specifications. Investigations and practical work have been developed as a central pillar of science over the history of science education. Science has changed from being assessed by essay and short answer recall of facts to pupils developing procedural and systemic knowledge about investigative science, which are assessed through coursework as well as by examination. The literature documented issues with the modular science approach to coursework, which was reduced to a few formulaic investigations. Science 2006, with coursework investigations to be completed in examination conditions was introduced to replace it. Applied science with a more vocational, coursework based approach to GCSE science education, was developed as an alternative qualification. Researchers found that pupils generally enjoyed practical investigative work, but time constraints were a limiting factor to getting high grades. The literature contained research concerning pupil views of the science curriculum up to 2007 and including the now removed modular specification. Gadd (2004) commented that no formal evaluation of the coursework-based applied science GCSE has yet been undertaken. There is a paucity of practitioner based research enquiries analysing the attitudes and perceptions of pupils to the applied and science 2006 specifications in the extant literature. Nor are there any studies of whether there are significant variations between the attainment of pupils, across the specifications, in coursework and examination grades in applied science and science 2006. This has sharpened my research focus and design in these areas.

Some teachers can see the value of investigative science and coursework as an important part of science. Other teachers have wondered what pupils learn from coursework and investigative work. Additionally, teachers may not be receiving the training they need in order to deliver and assess new specifications. Teachers also may feel that the changing specifications are being forced on them, and their only role is to deliver what they are told (Cater and Halsall 1998). McNally (2000) pointed out a lack of literature reflecting a teacher perspective on coursework and investigative science, and this has emerged as a focus for this research.

Constructivism has become the predominant paradigm for science teaching in the latter part of the twentieth century. Together, with the concept of active learning it has provided more focus on the ideas and preconceptions of individual learners and how they view and improve their work. However, in terms of the perceptions of pupils and teachers, there is a lot of evidence to suggest rote learning was often used to deliver modular science coursework. The concept of positivism is still alive in some coursework and exam teaching, even though the advantages of a constructivist approach have been espoused by many researchers. Coursework can be taught as rote learning, belying the want for active independent learning skills amongst pupils. The advent of applied science has given more varied coursework assignments, but not a perceptible change in the way it is delivered. The discussion-based approach of science 2006 has come under scrutiny. Science pupils learn in many ways and science curricula do not always reflect this. For this thesis, a developing theme is how pupils learn through GCSE science coursework, with particular reference to constructivism, active learning and rote learning.

Collusion in completing coursework has been countered by teachers warning and observing pupils at work, and checking completed work. Many students have admitted to cheating (Williams 2001) and parents have admitted to helping students with their coursework. Cheating can be related to extrinsic goals such as exam grades. Help from teachers is said to be poorly defined and open to interpretation (QCA 2006g). The advent of science 2006 coursework has provided less opportunity for collusion. A developing theme for researching the attitudes and views of teachers about coursework is the amount of help they feel they needed to give learners, and whether they view coursework learners to be independent and active.

There is a range of criteria through which the different coursework specifications are assessed. Assessment can be summative or formative. Summative assessment, in the form of examination grades are issued as a measure of performance (Brooks and Tough 2006). Feedback to students is an important part of formative assessment as it can guide pupils as to their strengths and weaknesses. Assessment for learning, which is related to constructivism, involves assessment from the teacher the pupil, and peers to provide feedback to modify and improve work, with the pupil the main user of the information.

Researchers have described how assessment for learning may improve attainment (section 2.5.4). As a teacher involved in planning, teaching, and assessing a changing curriculum I believe that effective assessment for learning, where pupils know clearly how to assess and improve their work, and can see their grade improve motivates pupils to work hard and increase their summative GCSE grade. A research focus has emerged to investigate the perceptions and attitudes of students and teachers to using active learning and assessment for learning to improve coursework.

Research has indicated that girls tended to achieve better coursework grades than boys, but their marks are less spread than for boys, indicating that coursework grades have more bearing on the overall GCSE scores for boys. There is evidence that girls and boys have interest in different areas of science, with boys showing a preference for the physical sciences, and girls for biology. Boys tend to be more positive in their views of exams than girls. However there are few differences in their perceptions of coursework. There is no data about this from science 2006 and applied science coursework and examination results, meaning that there is a gap in the literature concerning whether there are any actual differences in boys and girls attainment in coursework and examinations across the applied and Science 2006 GCSE specifications. This has emerged as a research focus which has influenced my research design.

The next chapter introduces the research questions that have developed from this chapter, and are central to this thesis. I have considered the advantages and disadvantages of the research methodologies I have employed, and explained how I have used them to answer my research questions.

Chapter 3

Research design, methodology and methods

3.1 Introduction

In chapter two, I researched the extant literature through the themes of curriculum, teaching, learning and assessment. This provides a backdrop against which my research questions are based. In this chapter I will introduce the research questions that drive this thesis. Following this, I will discuss the methods I have employed to collect and analyse data, and the methodologies that underpin them. The term methodology describes the philosophy behind different techniques of data collection. Methods are the procedures by which data is collected (Farmer and Rojewski 2001). I will consider the limitations inherent in my research and I will address a number of concerns connected with it, including ethical issues and the value, originality and uses of this research. I will also explain the principles that underpin my research design, which is a mixed methods study.

The value and uses of research projects, such as the project presented in this thesis, was espoused by Carter and Halsall (1998) who wrote of how they reassert the professional autonomy of teachers. They highlight the importance of teacher research in respect of the methodologies employed. Firstly, teacher research concentrates on aspects of teaching and learning. This is seen from an 'at the chalkface' perspective of implementing that learning every working day as part of professional practice. Secondly, teacher research helps to clarify and improve aspects of teaching with the important goals of improving student achievement, progress and development. Thirdly, the data used is systematically collected and analysed for a clear purpose connected to teaching and learning. This chapter is concerned with methods used for the collection of data, and their underlying methodologies. Later chapters discuss how the data is used to answer my research questions.

3.1.1 Research questions

Chapter two highlighted a lack of extant literature ascertaining the impact of coursework in GCSE science, since the introduction of applied science and science 2006. This thesis is an attempt to add to knowledge by providing a focussed study of GCSE coursework. The research questions that have driven this thesis are:

1) What are the perceptions and attitudes of key stage four pupils and teachers towards GCSE science coursework?

2) What are the variations in attainment between GCSE science coursework and examination study?

3) How do pupils learn through GCSE science coursework and examination study?

4) How effective, in terms of attainment of examination grades, is GCSE assessed science coursework for pupils' learning within the National Curriculum?

In order to address these research questions, an appropriate research methodology must be employed to ensure that a range of data of sufficient quality and quantity is collected and interpreted in order to process conclusions.

3.1.2 What methods have I used to address my research questions?

The overall approach of this thesis is that of a practitioner based enquiry, utilising mixed methods. Practitioner based enquiry research is undertaken by professionals involved in education, and involves reflecting on institutional practices in order to produce accessible reports and information (Murray 1992).My methodology has involved using qualitative and quantitative research methods to provide a range of data. Collecting qualitative data has given me a series of views and attitudes through questionnaires, interviews and observations, whereas quantitative data has provided me with information about significant differences in attainment and between numbers of participants expressing particular views. Thus, the possibility of bias by relying on one type of data is reduced by using a mixed methods approach, whereby both qualitative and qualitative approaches are combined to process and provide a conclusion (Tashakkori and Teddlie 1998).

I have addressed research question one by using questionnaires and pupil and teacher interviews, which are analysed and compared with the relevant literature in chapter nine. As Nieswandt, in Pitt (2005) pointed out, 'a variety of methods (questionnaires, student interviews and classroom observations) should be used to assess students' attitudes in science' (p.48).

I have answered research question two by employing statistical analysis of the summative results of coursework and examination study.

In answering research questions one and two, a particular dimension of these questions was to ascertain whether there were any differences in boys and girls attainment in coursework and examinations, and in their views towards coursework. There is a perception that coursework favours girls in terms of better GCSE performance (Elwood 1999). Male and female attainment in science is discussed in chapter two, section 2.4.7.

There are many ways of defining learning but for research question three I have focused particularly on three aspects I believe are meaningful for understanding the effects of examination study and coursework. These aspects are constructivism, assessment for learning and active learning. I have answered research question three by gathering observational data of pupils learning through coursework and examination study. I have added this to information from questionnaires and pupil and teacher interviews, and compared and contrasted my data with information from relevant literature in the conclusion.

I have drawn together all of the above techniques and strands of this thesis to process a conclusion to answer this final question, which examines effectiveness through the attainment of examination grades, of pupil learning of science.

The overall framing of the research is based upon a case study of one school and is bolstered with additional data from other schools. It is a longitudinal study over a three year period.

3.1.3 The contextual background to this research

This research was set against a background of change within science at GCSE level. The old double award science was being phased out with many specifications ending in the summer of 2007. Applied science GCSE was introduced to provide a vocational coursework based alternative alongside the new science 2006 curriculum, which most pupils studied by the 2007/8 academic year. In science 2006, pupils study a core science worth one GCSE, which is assessed by examination and coursework, and opt for a second GCSE, which could be the same format or applied. Whilst this happened, some higher achieving pupils took separate science GCSEs in physics, chemistry and biology, which were assessed in the same way as the original double science until the 2007/8 academic year when they were assessed in the manner of science 2006. The changes to GCSE science are discussed in more detail in chapter two, sections 2.2.4 - 2.2.6. Within the context of the school in which I worked the national change was mirrored. Modular double science examinations were taken for the last time in 2006. Applied science double GCSE was introduced for middle achieving pupils who were mostly predicted grades D-E with the first cohort finishing their qualification in the summer of 2006. Higher achieving pupils began taking single award GCSE with the first pupils completing their qualifications in 2007. In the autumn of 2006, science 2006 replaced applied science for middle and lower ability pupils with applied science existing as a second GCSE award for those taking science 2006. This raises the question of what it is that is being taught, learned and examined as a curriculum and provides evidence of uncertainty and doubt about the science curriculum and points to the need for this kind of research. The changes were documented each year that the research was undertaken. This is also why I have indexed each section of my research in chronological order; it allowed me to catalogue the attitudes and results each year of this change and ascertain any differences.

3.2 Pacing and the time period involved

The pacing of the qualitative research involved planning the sequence of components and moving between data collection and analysis. This enhanced the reliability of the study; the consistency, replicability, precision and accuracy of the testing and sampling over time (Cohen, Manion and Morrison 2000) and ensures that there is less bias in the data by obtaining results at different times in different years of the study, for example, where coursework may have been thought about less, as it was not being taught all year. Attention to chronological sequences is a key component of research design (Yin 2003).

My research was paced accordingly:

1) Questionnaire and interview data were collected from pupils in the spring and summer terms (Jan – April, April - July) of each year. This allowed for pupils particularly to gain some experience of coursework so that they could formulate opinions for questionnaires and interviews. I used the remainder of the year to analyse the data. The research began in the autumn of 2005, the start of the final academic year of double science GCSE in the school I worked. It was also the academic year in which pupils completed the applied science GCSE for the first time.

2) Interview data from teachers was collected in the summer term (April – July) when year eleven had finished. Teachers had recent experience of teaching coursework and theory to year eleven pupils who will have left for examinations. I used the remainder of the summer term to analyse the data.

3) GCSE examination results data was collected when it was published in the summer (August) and I used the remainder of the year to analyse it.

4) Observational data (learning approaches sheets) of pupils completing coursework and class work and field notes of pupils and teachers were collected throughout the year.

The forthcoming sections will address the methodology underpinning the project.

3.3 The longitudinal nature of the research

There are certain disadvantages to a longitudinal study. The continual changes of staff, pupils and teaching methods can, according to Cohen and Manion (1994), lead to problems in terms of the organisation and design of the study. This study is concerned with the views and academic results of different pupils amongst the GCSE science cohort over the years. It is this change of pupils, as they study different specifications, which provide the data to discover the strengths and weaknesses of GCSE science coursework over time. There is also the problem of control effects, where the repeated interviewing of participants can influence their behaviour, and makes them more aware of the issues being studied (Menard 2002). The GCSE science courses I have analysed take two years to complete, and there was a chance that pupils may have completed questionnaires, or took part in interviews twice, with a year separating each instance. Therefore some participants may have had their awareness of coursework issues heightened. Bias inherent in the research design may be exacerbated by the repetition of sampling techniques in a longitudinal study according to Menard (2002).

'The vast majority of studies in the social sciences are conducted at one point only in time thereby ignoring the effects of social change and process' (Cohen and Manion 1994 p.236). This study took place over three years, and analysed the impact of new science courses alongside more established ones. The research methods of interviews, questionnaires, observations and t-test analysis of exam and coursework results were repeated at set times every year. It is therefore a longitudinal study (Cohen, Manion & Morrison 2000). A study is longitudinal by 'describing and assessing change over time' (Robson 1996 p.50). Saldana (2003) described a minimum of seven months is required for a study to be described as longitudinal. He explains change in a longitudinal study as something that emerges as data is analysed. Longitudinal studies enable the researcher to study and assess the process of change and transition, and how people react to it, without the 'snapshot' effect of static data whereby the data may not explain the direction of change, for example to ascertain whether applied science results have improved over time (DesJardins in Smart ed. 2003 p.426). The longitudinal nature of this study involved tracking a cohort, a specific group of people (GCSE science pupils), as science specifications changed over the time span of the investigation from modular science to applied science and science 2006. It is a trend study (Cohen and Manion 1994) in that the same factors were investigated over the three years of the investigation to different members of the GCSE science cohort. The trend study 'examines recorded data to establish patterns of change that have already occurred' (Cohen and Manion 1994 p.175).

Working with data obtained from three years of study has enabled me to monitor the change from modular science to science 2006 and applied science. This study did not use static data or one off interviews, which may produce answers specific to one time and situation only.

3.4 Case studies – strengths and limitations

Scope is the 'domain of enquiry, the coverage and reach of the project' (Morse and Richards 2002 p.67), which can be defined through my research questions. The thesis covers questionnaire and interview data from a number of schools, alongside observational and results data from the school where I was employed. Difficulties in obtaining the detailed results data needed from other schools have given the project the standing of a case study concentrating on one institution, but offset with some data from others, which may help to address any problems of bias perceived within case study projects. This approach was methodologically appropriate to the research questions, as case studies provide examples of real situations and people to show how ideas, such as the changes in GCSE science, operate in reality (Cohen, Manion and Morrison 2000). A case study contains specific information concerning an institution or a group of people, according to Patton (1990). Case studies are valuable, as they 'can provide new insights that are quite different from those generated by broader studies' (Libarkin and Kurdziel 2002a p.196). They considered that case studies should consist of a great deal of varied qualitative data including interviews, observations and are often layered, as they take part over a long period of time, as is the case with this one. Case studies can be interpretive and subjective: 'a focus that complements the experimental stance' (Cohen and Manion 1994 p.106). Bassey (1999) described the value of case study in that 'it [case study] is expected in some way to be typical of something more general. The focus is the issue rather than the case itself' (p.62). Thus, this study has investigated the views of pupils and teachers towards the science coursework that they work with, and how pupils learn through examination and coursework, through a case study approach, and the results can be interpreted more generally.

My research consists mostly of a case study of one institution, although bolstered by data from other schools, and contains participant observation. Such case study research can be both participant and non-participant based. Mine is both, as I used some questionnaire and teacher interview data from other schools, as a non-participant. However most of my work was participant based; as the participant I was involved in what is happening in the study. As a participant teacher, obtaining data from questionnaires and group interviews allowed me to gain research data in a normal classroom setting where pupils expected to see me. A case study in a small setting such as mine will have only a limited range of circumstances to which any conclusions will apply (Libarkin and Kurdziel 2002a). Cohen, Manion and Morrison (2000) take up the same point, writing of external validity and whether the results of a study can be generalised to the wider population. However, case studies do provide more detailed focus on processes that are not possible in broader studies, giving 'the thick descriptions that are useful in ethnographic research' (Cohen and Manion 1994 p.152). They also describe the tacit knowledge added to such research by the researcher, and the importance of the interactions between researcher and subjects that highlight their involvement in the research. Added to this, any conclusions should have a positive effect on the teaching and learning in the setting of the study. Also, as no study has yet been made of the teaching and learning of applied science or science 2006 then it has originality and the conclusions drawn also provide useful insights into teaching and learning across GCSE science teaching.

The advantages to holding longitudinal, detailed case studies were explored by Cohen and Manion (1994): 'because case studies take place over extended periods of time, researchers can develop more intimate and informal relationships with those they are observing in a more natural environment' (p.110). As a participant researcher in situ, I was able to conduct my research in a natural environment in which the pupils knew me and my position as their teacher.

The dynamics that could affect a case study were considered by Sagor (2005). For example, if pupils could be offered payment or other incentives by their parents to get good coursework grades. Intervening variables such as this can have an effect on the research outcomes (an example is if pupils from a feeder school achieve better grades from average than another). I may then conclude that this school teaches coursework skills more effectively. I may not have taken into account the socio-economic factors and the catchment areas that affect which feeder schools pupils attend.

Disadvantages of case study reports include perceived bias and idiosyncrasies (Cohen and Manion 1994). As they pointed out, case studies are subjective and interpretive, so where does subjectivity become bias and an original interpretation become an idiosyncrasy? Bias and subjectivity could be perceived in my case study, as I was embedded in the organisation where a good deal of my research took place and this could be a negative factor to weigh against any conclusions I developed. However, I have strived to produce an original interpretation of my data, using a mixed methodological approach of using different types of data to reduce bias. As Holmes (1989) wrote 'fieldwork is personal...The theoretical separation of self from other is not so easily accomplished in fieldwork with children' (p.26). She wrote of the difficulty in dividing the professional from the personal in such research. Fieldwork is never completed in a vacuum. It should though, according to Mason (2004), involve self-scrutiny by the researcher. This involves the researcher acknowledging their position in the research process. The findings from a reflexive position are always a reflection of the researcher's location in time and social space (Bryman, 2004). Personal experience can shape the definition of the research problem and the methods used to collect and analyse data, and can also be a source of data about the research problem (Ezzy, 2002). I worked as co-ordinator of applied and vocational sciences in the English secondary school system, and I conducted the research as a participant observer. I am aware that I have utilised my personal and professional experience, knowledge, and viewpoints in this thesis, which may have affected my objectivity when dealing with, and interpreting, ideas and viewpoints similar to my own.

The case study approach in this research consists of one large study of a secondary school over three years, consisting of a range of data analyses, although bolstered by interview and questionnaire data from other schools.

As an employee involved in implementing and working through change, a case study analysis has allowed me to view the school as an example of a system in flux and to ascertain how that change has affected people who work or study there.

3.5 Combining methods

> Qualitative analysis provides the context lacking in quantitative research, and quantitative analyses broaden the implications of a purely qualitative study (Libarkin and Kurdziel 2002a p.80).

My research questions were structured to explore the views, attitudes and differences in GCSE coursework and examination results. By combining qualitative and quantitative methods I have combined qualitative attitudes, experiences and views with data values inherent in quantitative analysis. Neither qualitative nor quantitative methods are mutually exclusive in research design (Newman and Ridenour 2007). By mixing the quantitative and qualitative methods in the research questions, data collection and analysis, this thesis is a mixed methods study.

Qualitative and quantitative methods stem from different methodological standpoints (Newman and Ridenour 2007). Quantitative research is positivistic, with the assumption that there is a common reality which people can agree on. It is used for establishing facts. It is normative, according to Cohen and Manion (1994). Normative describes human behaviour as rule governed and that it can be studied using the scientific method. Qualitative research is naturalistic, and from an individualist phenomenological perspective. It is related to a constructivist epistemology where individual perspectives differ. There are no established facts; social phenomena are in a constant state of revision. Qualitative studies are interpretive in that they underline a concern for the individual within an overall concern of 'the subjective world of human experience' (Cohen and Manion 1994 p.36).Qualitative and quantitative methodologies are not mutually exclusive, according to Newman and Ridenour (2007) and combining them in a mixed methods approach provides a powerful paradigm in which to conduct research (Tashakkori and

Teddlie 1989). Different types of data can be interpreted using the qualitative and quantitative approaches. Interview data can be quantitatively analysed for significant differences in numbers of opinions about certain topics, and quantitative data can be used to enrich qualitative results. 'Quantitative data is not necessarily defined by numerical data and qualitative research is not necessarily defined by textual data (Newman and Ridenour2007 p.14).

Quantitative and quantitative methods 'have strengths, and even greater strength can come from their appropriate combination' (Gorad and Taylor 2004 p.1). Also, 'research claims are stronger when based on a variety of methods' (Gorad and Taylor 2004. p.7). The idea of such research was described by Mouly (1978) quoted in Cohen and Manion (1994) who stated how it is 'best conceived as the process of arriving at dependable solutions through the planned and systematic collection, analysis, and interpretation of data' (p.40). This is turn may be scientific, which Black (2004) describes as being 'specific, well focussed and systematic' (p.75). It is empirical, involving information, knowledge and understanding gathered through experience and data collection (Black 2004). Scientific research encompasses a concept of control: isolating and testing causes (Cohen and Manion 1994). However, I worked with pupils in their school context, as it was not appropriate to do this in a laboratory setting. A study such as mine in the social sciences involved observing pupils and collecting data produced by them such as questionnaires and interviews, examination and coursework grades. My study did not begin with a hypothesis such as a statement like 'coursework is more popular than examinations and produces better grades'. Instead it is a case study, which collected and analysed data to come to conclusions about the nature of coursework and exam based study in line with my research questions.

The design of mixed methods research studies was discussed by Tashakkori and Teddlie (1989). This study is a parallel / simultaneous mixed methods design according to their rationale, wherein data, both qualitative and quantitative, are collected and analysed together, at regular intervals, and form part of the research enquiry, following on from the research questions.

Consistency was enhanced by utilising the same interview questions (although added to in the second and third years of the study in order to collect additional data), questionnaires, observation sheets and statistical tools over the three years of the study.

Data validity was increased by using a mixed methodology approach. This included obtaining a large amount of data over a three year time period in order to ascertain to what extent conclusions can be generalised as representing reality, and in my skills and sensitivities in interpreting the data (Sparkes 1992) . Researcher bias was decreased by having colleagues and tutors check my results and observational data to consider critically the inferences I have made, and from having support assistants and trainee teachers assisting with interviewing groups of pupils.

Therefore, I combined qualitative interviews, observations and questionnaires alongside quantitative statistical methods to progress results and make conclusions that have answered my research questions in a mixed methods study. Combining methods in this way can be 'so powerful in practice' (Gorad and Taylor 2004 p.176).

3.6 Quantitative data: purposes, management and relevance

Quantitative methods are generally used less frequently than qualitative methods in educational research. A study showed that over half the respondents to a survey about educational research did not use quantitative methods (Gorad and Taylor 2004). Nasser, writing in Farmer and Rojewski ed. (2001) described a quantitative approach as one where 'researchers seek explanations and predictions that allow for generalisations' (p.93). The nature of quantitative data when it is used was considered by Libarkin and Kurdziel (2002b). They found that even in the most controlled study, data is never purely quantitative, as the context of the study and the perspective of the researcher always intervene. The validity of quantitative data was considered by Cohen, Manion and Morrison (2000). They claimed that validity can be achieved through careful sampling and appropriate statistical analyses.

Quantitative analysis adds precision, in terms of the significance of differences between data sets. Such numerical analysis was intrinsic in addressing research question two: 'what are the variations in attainment between GCSE science assessed coursework and examination study?' I employed quantitative analysis to investigate whether significant differences existed between coursework and examination results in the different science subjects. I also employed quantitative tools to investigate possible significant differences between questionnaire responses, for example between pupils studying different specifications, and between boys and girls, to address research question one: 'what are the perceptions and attitudes of key stage four pupils and teachers towards GCSE science coursework?'. According to Robson (1996) a significant difference occurs when values, scores or observations obtained under one condition, differ from those obtained under another condition, and this difference is very unlikely to be due to errors (for example, if there are large differences between coursework and examination scores in one specification, and statistical analysis proves that this is very unlikely to be due to chance, the difference can be described as statistically significant).

Statistical significance differs from methodological significance, which is measured by the validity of the data used, and the methods employed to collect it. The internal validity of the data refers to what extent the findings I describe are due to differences in coursework and examination attainment rather than other extraneous variables (Black 2004). The external validity of my results refers to the general applicability of my findings beyond the case study of this thesis (Cohen, Manion and Morrison 2000, Black 2004), which I have discussed in section 3.4.

The data I collected came from GCSE examination results published by the examination board AQA from the main school of this study. The results were broken down into their component parts: examination and coursework UMS marks. UMS marks come from the Uniform Mark Scheme; a method employed by the exam board to convert 'raw' grades into scores from a maximum, e.g. 700 was the maximum UMS mark for modular science. The coursework had a maximum mark of 64, which was scaled up to 140 to ensure that it formed 20% of the overall mark. I converted the UMS marks into percentages for coursework and examinations. Modular foundation and higher scores were marked on different scales to allow pupils taking the higher paper to achieve grades A* - B whereas the maximum mark in the foundation exam was C. For this reason I applied some analyses to the higher and foundation results separately.

I used the t-test specifically to discover whether significant differences existed between examination and coursework results across the modular, applied and science 2006 specifications, and between male and female examination and coursework results, in order to respond to research question two: 'what are the variations in attainment between GCSE science assessed coursework and examination study?'. The t-test, according to Black (2004), is to 'compare two groups for some trait to see if they are sufficiently dissimilar that we can say they do not belong to the same population' (p.402). Within the groups, the mean of each group is compared and judged relative to the spread or variability of their scores. The null hypothesis states that there is no difference between the means. The ratio is calculated and checked against a table of significance to ascertain if the ratio is large enough to say the difference in grades is significant, in that the trends or results in the data set are not random or created by chance and that it is possible to say, with a stated level of confidence, these differences appear to apply and are statistically significant.

There is the inherent assumption in using t-tests that the different groups tested must be independent. The independence in my data came from the coursework and exam results for pupils being independent of each other. Each had separate marking schemes, and was recorded separately as part of each pupil's overall results. I used Excel to calculate t-test values for exam and coursework grades. I used the two tailed version of the t-test which assumes a null hypothesis of no difference between data sets (Black 2004, statpac.com 2006). The two tailed test is the most commonly used t-test, as it reduces type one errors, where differences are seen in the data, but in reality there are none (Black 2004). My values for the t-test were checked against critical values in Black (2004) and if they were higher, then the null hypothesis that there is no significant difference between data sets could be rejected. The t-test assumes two less degree of freedom than the both data sets combined ($df = nA + nB - 2$) needed to get a mean and I checked the values against t-test tables for critical values in Black (2004).

The statistical values of the data were checked against tables of significance, at the appropriate degrees of freedom, where a set percentage of normal results for the test would fall below a certain level (Sardar, Ravetz, Van Loon 1999, Ryerton University 2006). If my results were above the set level I could be confident that there were significant differences between samples. I tested my samples at three different probability levels detailed on table 3.2 to determine if there were significant differences, and if so, to what degree those differences existed. Table 3.2 provides a guide to significance. As Chang (1997) discussed, levels of significance are arbitrary, depending upon at what number the levels of probability are set. For example, if a data sample was very close to, but not at, the level for the result to be highly significant, it would still be closer to that level than to being merely significant. I have taken this into account when analysing my samples.

Table 3.1 Degrees of statistical significance

Probability	Likelihood of result occurring by chance	Significance
0.05	1 in 20	Significant
0.01	1 in 100	Very significant
0.001	1 in 1000	Highly significant

A problem that may arise from doing multiple t-test analyses is that type one errors may occur. To counteract this, I have employed the Bonferroni correction, which is a statistical adjustment for multiple comparisons (Cramer and Howitt 2004). At the 0.05 level, there is a probability that one in 20 statistical tests will indicate that two groups differ by chance, when in reality they do not differ (as shown in table 3.1). Where I have tested multiple data sets, there has been a greater likelihood of one of my tests indicating such a result. By using the Bonferroni correction, I have reduced the significance level by dividing it by the number of comparisons I have made (Cramer and Howitt 2004). A researcher wanting to compare six groups at the 0.05 level would divide 0.05 by six, to give a significance level of 0.008. One problem of using the Bonferroni correction, according to Cramer and Howitt (2004) is that it may increase type two errors, where no difference between groups is assumed, but in reality there is a difference.

Using a qualitative approach has given increased validity to the data by establishing that where trends or results in the data are not random or created by chance, it can be declared with a stated level of confidence that significant differences appear to apply. It has allowed me to process responses specifically to research questions one and two, in conjunction with qualitative data as a mixed methods study. The qualitative approach is explained in the next section.

3.7 Questionnaires

Research using questionnaires involves 'trying to measure and quantify how intensely people feel about issues as opposed to what they know or can do' (Black 2004 p.215). My questionnaires involved collecting the opinions of students, quantifying the numbers who expressed certain opinions. In this way, qualitative data is intrinsically related to quantitative data and can indeed be converted from words and opinions into numbers. It is a process where collecting data and analysing data are not separate (Morse and Richards 2002).

My research questions aimed to ascertain the perceptions and attitudes of pupils and teachers towards coursework (question 1) and to look at any variations in attainment in coursework and examination study (question 2). Hopkins (1993) considered questionnaires as a 'quick and simple way of obtaining broad and rich information from pupils' but only if they ask 'specific questions of the classroom, curriculum or teaching method' (p.134). I have used questionnaires to answer question one and to complement the quantitative data I have used to answer question two. Questionnaire data also provided evidence from teachers and pupils for research question three: 'how do pupils learn from GCSE assessed science coursework and examination study?' and for question four: 'How effective, in terms of attainment of examination grades, is GCSE assessed science course work for pupils' learning within the National Curriculum?' Caution in relying only on questionnaire data comes from Black (2004 p.215): 'Researchers must be careful about drawing unwarranted conclusions, making extreme generalisations or stereotyping respondents'.

Questionnaires have been described as being 'the most commonly used descriptive method in educational research' (Cohen and Manion 1994 p.83). They were versatile in that I asked colleagues in another school to distribute them so that they could be completed by a large number of pupils (section 3.14). As I was working full time, they afforded me an opportunity to access responses I would otherwise have been unable to reach and build up a picture of student responses in a number of schools. Questionnaires should be treated with care, as student responses were constrained by what I chose to ask them (Cohen and Manion 1994).

Qualitative data contains many variables, and as such is open to a range of interpretations. It was my role as a researcher to formulate conclusions, themes and effects. Unlike quantitative data, which is bound to statistical rules, qualitative data must have its reliability and validity established for it to be presented to others. I had to assume the respondents answered questionnaires honestly and accurately when they were given out in a classroom setting. Also, as they were voluntary, how would the thoughts of those who fail to complete them alter results? However, there is a greater reliability in questionnaires than interviews due to their anonymity (Cohen, Manion and Morrison 2000).

My questionnaires were designed to gather data at particular points in time during the spring term from January to April. This allowed year ten pupils to have had at least a term's worth of coursework and theory to reflect on. It also allowed year eleven pupils who had five terms of coursework and theory and who were feeling the pressure of coursework and exam deadlines to express their thoughts. The questionnaires were given out at the start of lessons and individuals were told to answer them alone and without talking to, or checking the responses of others. I monitored the pupils as they completed them, to guard against collusion, and gave a limited time for their completion, to ensure pupils did not finish their questionnaires quickly and then compare their results to those of their peers. This gave me enough data to 'describe the nature of existing conditions or identifying standards against which existing conditions can be compared or determining the relationships that exist between specific events' (Cohen and Manion 1994 p.83). Those conditions/events were coursework and theoretical studies and attitudes towards them.

Sampling through questionnaires, I aimed to gain enough information from a subset of the school population in order to gain enough knowledge to be representative of the total population of KS4 pupils in the case study school. Cohen and Manion (1994) pointed out: 'thirty is held to be the minimum number of cases if researchers plan to use some form of statistical analysis on their data' (p.89). My sampling was a form of what Cohen and Manion (1994) described as 'non probability sampling' (p.88) where each member of the population under study, at least in the place where I work, had an equal chance of completing a questionnaire. Non probability sampling is usually used case studies. A subdivision of non probability sampling is convenience sampling. In this the nearest individuals i.e. pupils in my classes are chosen to act as respondents. Another option is quota sampling: choosing a number of appropriate representatives e.g. boys and girls. Due to the relatively small number of responses I recieved, convenience sampling was the most appropriate method, particularly when some of my responses were collected by colleagues working at other schools.

The design of my questionnaires was kept deliberately simple. This allowed pupils to quickly ascertain what they needed to do and complete them in classes without interrupting their learning time. It allowed colleagues at other schools to use them efficiently. Clarity of instruction is essential to a good questionnaire according to Cohen and Manion (1994). I felt it important to explain to colleagues the reasons for my research, as all participants to my research needed to know the purpose and possible outcomes of it. An example questionnaire is shown in appendix 1, and three completed questionnaires are shown in appendix 3.

A good questionnaire should be clear and unambiguous to avoid mistakes from the respondents and from my decoding of them (Cohen, Manion and Morrison 2000). I framed and tested previous versions of my questionnaire to ascertain the accuracy of the questions and ease of layout before wholesale use. A sample population of twenty two pupils were used to test the ease of filling in the survey, the likelihood of making mistakes when answering and any other comments. Prior to this study, I used similar questionnaires with success (Gerrard 2005, and during the initial research for this study in the academic year 2005-6), so I was not envisioning that major changes would need to be made. The class were given ten minutes to complete the questionnaire and then I asked for views on it.

When asked if the questionnaire was easy to fill in, seventeen put their hands up to acknowledge. When asked if they made any mistakes when filling in the questionnaire, only one person replied in the affirmative. This agreed with my checking of the sample where one sample contained crossed out and re-circled answers (Field note T11S1C1 05/10/2005 – field note coding is explained in section 3.7).

When asked for any other comments, there were a number of replies of 'boring' although one pupil thought it interesting that their opinions should count for something. No pupils mentioned the layout of the sheet being drab specifically although the boring comments could have been applied to this specifically. I did not extrapolate as to the meaning of the 'boring' comments, although thinking back this may have proved worthwhile in working out whether the layout and / or the questions were boring. The open ended question was popular with pupils agreeing that they liked the idea of having *their* say as part of the questionnaire.

The questionnaire employed Likert scales. Their use is defined by Black (2004) as 'a list of declarative statements and asking respondents to rate them in terms of agreement or disagreement' (p.227). Black (2004) pointed out that Likert scales use between three and seven responses per question. I decided to use a three point scale to provide simplicity for the respondents, whilst still reflecting my research questions and providing valid answers. Having an odd number of choices, such as three, allows people to take a neutral point of view rather than to take a stand, which they would have to if there were an even number of choices (Russell Bernard 2000, Black (2004). A three point scale allows for positive, negative and neutral responses. However, a neutral point according to Cohen, Manion and Morrison (2000) can sometimes cause people to opt for the middle value. This is a possible criticism of my use of Likert scale data which could be overcome in future research by using an even numbered scale where there is no midpoint, which would require participants to make a decision. However, in ascertaining the attitudes and perceptions of learners, it can be appreciated that some participants may genuinely be unsure or have a neutral point of view: 'if respondents wish to sit on the fence and chose a midpoint, then they should be given the option to do so' (Cohen, Manion and Morrison 2000 p.327).

Five of the seven questions have the following Likert scale:

Agree	not sure	Disagree

This allowed for definite answers either for or against certain statements.

Question six has a different vocabulary related to the wording of the question:

Too little	the right amount	too much

Having more questions gives a higher degree of reliability (Black 2004). I had to balance this against an upper limit of questions whereby the respondents would not tolerate having so much to write or think about. With this in mind I chose seven specific questions. This was alongside specific information at the top of the questionnaire concerning the sex of the respondent and the type of science course they were undertaking. This information helped me in researching differences in attitudes between those studying different subjects and between the sexes.

The seven questions were written in order to not appear too complex and to be short (less than twenty words) clear and concise (Cohen and Manion 1994, Black 2004).

Question 1: '**I prefer doing coursework to exams?**' aimed at answering research question one and also question four by ascertaining an initial viewpoint on their preference, which also may be related to the effectiveness of coursework.

Question 2: '**I have enjoyed doing the Science coursework?**' built on the idea of question one but relates specifically to science rather than the general concept of coursework and again helped to find answers for research questions one and four. The answers to these questions were contrasted with and statistical variations in coursework and examination grades. The responses were also be used to answer research question three: if pupils enjoy and hold a preference for coursework do they learn more effectively by being more motivated?

Question 3: '**I work hard in coursework lessons?**' enquired whether pupils perceive coursework to be a challenging option: did it encourage them to work hard or to sit back and do very little. The effectiveness of coursework mentioned in research question four is addressed here.

Question 4: '**I get stressed about coursework?**' addressed the notion that students found coursework deadlines and the task of writing and improving successful coursework stressful. This addressed the effectiveness of coursework and attitudes towards it expressed in research questions four and one respectively.

Question 5: '**I get stressed about exams?**' is a counterpart question to question four that explored any notions of differences between examination and coursework stress.

Question 6: '**Do you think you get the right amount of coursework in all subjects?**' explored the role of coursework across the curriculum. Pupils may have felt that they were overwhelmed by coursework across all subjects, as Bishop, Bullock, Martin and Thompson (1997) asserted. They may have felt that their coursework was beneficial to them. This targeted research question one.

Question 7: '**Are you able to tell what grade your coursework is at and how to improve it?**' was directed at pupil knowledge of assessment for learning. The question asked to what extent pupils were aware of how they could improve on their work and if they felt they had enough information to assess to where they had got. I added this question to the 2006/7 questionnaires to address research question three.

The final question was open ended in order to explore any other issues the respondents may have had. Open ended questions were described as being too vague and unlikely to persuade respondents to address the issues concerned (Black 2004). Cohen and Manion(1994) also advised against open ended questions stating that they 'are too demanding of most respondents' time'(p.94) However, Holmes (1989) was concerned with 'listening to what children say rather than working with a prior agenda' (p.78) and it is with this in mind I used an open ended question to finish. Even if a number of respondents left it blank (which I told them is not a problem) or produce trivial answers, a few interesting or insightful responses made it worthwhile, and it allowed the respondents to feel that they were being given an opportunity to explore their viewpoints.

Following the collection of questionnaire data I had to ascertain a number of things in my editing of it. I had to check for completeness: were all of the questionnaires completed correctly? A measure of the success of my questionnaires is that nearly all of them were completed without mistakes. I have also had to check my own coding: whether I have totalled up all of the numbers and percentages of answers correctly and accurately.

I made changes to the basic layout of the questionnaire to ascertain the views of pupils about whole afternoons / mornings of coursework in the 2005-6 academic year in chapter four, section 4.3. Such a flexible approach allowed me to gain information about such activities where and when the opportunity arose. I explained how and why the questions were changed in the relevant chapter sections.

The data I have collected have been processed into percentages to emphasise the responses to each question. I used this data to ascertain differences between boys and girls responses and those studying different forms of GCSE science.

3.8 Qualitative analysis

By definition, quantitative data consists of numbers, whereas qualitative data is made up of words 'either created directly by those under study or passively by the researcher' (Libarkin and Kurdziel 2002a p.195). However, qualitative analysis involves human behaviour, which is a function of the setting in which it is being observed, i.e. the classroom. Qualitative validity is enhanced by a diverse set of views that overlap and can consist of multiple truths, that the researcher must interpret based on shared visions and understandings (Sparkes 1992).

Qualitative data can be broken down into three categories according to Patton (1990) and Libarkin and Kurdziel (2002b):

1) Interviews, to include focus groups
2) Direct observations
3) Written documents including surveys

In order to address research questions three and four: 'how do pupils learn from GCSE assessed science coursework and examination study, and what is the role of active learning?' and 'how effective, in terms of attainment of examination grades, is GCSE assessed science coursework for pupils' learning within the National Curriculum?' aspects of my research involved using questionnaires, which would fit into category three and direct observations; category two. To address research question one: 'what are the perceptions and attitudes of pupils and teachers towards GCSE science coursework?' an element of interviewing of key groups, parents, teachers and pupils was important. Qualitative data can be converted from words and opinions into numbers and as such is intrinsically linked to quantitative data, according to Morse and Richards (2002). Within the above research techniques, I have used numerical methods to categorise and analyse the data, for example the number of interview respondents expressing a certain opinion, and possible reasons why.

Validity in qualitative analysis comes from the honesty, depth, richness and scope of data (Cohen, Manion and Morrison 2000) and the skills and sensitivities of the researcher (Sparkes 1992). By using, and analysing, varied data forms over a period of years I have achieved these points. Qualitative analysis has given this project a range and depth of rich data in order to analyse and process responses to research questions one, three and four.

3.8.1 Interviews

Interviews present an opportunity to gather useful information towards research objectives by gathering research relevant information (Cohen and Manion 1994). According to Anderson and Arsenault (1998), interviews represent the most commonly used educational research method. Ribbins (2007) points out that it is only by listening to people that a researcher really finds out what it is like to be in a particular role in a school. I used interviews with pupils and teachers in order to respond to research questions one: 'what are the perceptions and attitudes of key stage four pupils and teachers towards GCSE science coursework?', three: 'how do pupils learn in GCSE science coursework and examination study?' and four: 'how effective, in terms of attainment of examination grades, is GCSE assessed science coursework for pupils' learning within the National Curriculum?'

Interviews can be conducted one to one or with focus groups. One to one interviews with pupils could raise ethical issues of informed consent and the interviewer being in a room alone with a pupil (University of Gloucestershire 2009b). They can also be time consuming when compared to focus groups. For exploring the perceptions and attitudes of teachers and parents it may be unrealistic to assemble focus groups of these people, as lack of time and availability may be problematic. Therefore, short interviews and written documents would be more appropriate.

Powell, Single and Lloyd (1996) defined a focus group as being 'a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research. (p. 499). There can be as many as 15, and as few as three participants in a focus group interview, according to Gibbs (1997). There are advantages and disadvantages to the use of focus groups. They 'can lead valuable information concerning group dynamics and peer dynamics' (Libarkin and Kurdziel 2002b p.196), and can provide a range of responses and discussion according to Cohen and Manion (1994). Focus group research can draw upon the attitudes, feelings, beliefs, experiences and reactions respondents' in a way in which would not be possible using other methods, for example observation, one-to-one interviewing, or questionnaire surveys according to Gibbs (1997) . These attitudes, feelings and beliefs could be partially independent of a group or its social setting, but are more likely to be revealed through the social gathering and interaction of being part of a focus group. The speed and flexibility of the focus group approach was highlighted by Threflall (1999). She also noted that because focus groups allow for participant focus rather than researcher emphasis, they can capture the meaningful experiences and ideas of the participants on a given topic.

The questioner can take the lead, and prevent interviewees from disclosing important information by leading the interview away from them (Threlfall 1999) although this may raise questions concerning the validity and bias of responses collected in such a way. Group dynamics can also influence the views that participants may offer. According to Threlfall (1999) 'Many participants will give up their true convictions so they will not cross the consensus of the majority. Others find themselves agreeing with the plurality ideas and values simply because they do not feel as personally responsible for the outcome of the group' (p.104). Gibbs (1997) expressed similar sentiments, and also warned that the participants used in focus groups may not be representative of a population. These are features that need to be considered in interviews so that interviewees are encouraged to express their views as fully as possible without the interviewer detracting from the process. The role of the interviewer in such cases is to be as neutral as possible, whilst facilitating the interviewee(s) to express their views clearly and comprehensively.

Interviews can be classified as unstructured, semi-structured or structured. An unstructured interview contains an open invitation to discussion, while a semi structured interview contains few prepared questions and allows the interviewer to listen to and learn from the participants (Holmes 1989, Morse and Richards 2002). Unplanned and unanticipated questions can then be used, depending on the way the interview is heading. The virtues of unstructured and semi structured interviews were espoused by Holmes (1989), who complained of the 'threatening and anxiety provoking' nature of structured interviews and that less structured interviews allow researchers to devise, hypothesise, generate theory and access pupils' thoughts (p.61). Holmes (1989) also wrote of the problems of male researchers being treated with suspicion by pupils if they are unfamiliar, which did not pose a problem for me. Cohen, Manion and Morrison (2000) took a different view, stating that structured questions allowed for less bias. They claimed that leading and unstructured questions were more likely to lead to interviewers obtaining answers that support their ideas.

I conducted my interviews with small groups of pupils in a classroom setting whilst I was teaching their class. I set up coursework related tasks for the class to do in groups such as finishing a particular piece or component of coursework. I then visited groups of between two and six pupils as they worked and asked them a series of questions in a semi-structured format. The minimum number of interviewees required for a focus group is three, according to Gibbs (1997), so working with as few as two students did not classify all of these interviews as being with focus groups on this basis. The classes were selected as they were studying the requisite applied, modular or science 2006 courses.

There were a number of reasons for carrying out interviews in the classroom. Firstly, carrying out interviews outside of the classroom environment could make pupils feel they have done something wrong, and could create an artificial environment where they would not express their feelings (Holmes 1989). Another factor is time. As a full-time teacher with responsibilities, I simply did not have the free time to take pupils from lessons to interview them. The school had very short lunch and break times, and it was not feasible to use these times for interviews. It had to fit around their learning and my teaching. Some group interviewing techniques involve the use of a tape recorder (Morse and Roberts 2002), but I felt that this would jeopardise the chances of obtaining free responses, as some may have felt uncomfortable about their opinions being recorded, even with guarantees of anonymity. I used a pen and paper to note responses by individuals during the interviews. This could have led to issues of recall, where, for example, more than one person was talking at once. In such instances I had to ask for one response at a time, giving me time to note their responses.

A problem with such group interviews could be that only some in the group would respond and tend to dominate proceedings. This is summed up by Cohen and Manion (1994) who consider that the dynamics of group interviews can prevent personal data from respondents emerging. Another factor may be that because of my position of authority pupils may have given answers that they wanted me to hear rather than give honest viewpoints. This problem is highlighted by Cohen and Manion (1994) as a form of bias from the characteristics of the interviewer and respondents and the substantive content of the questions. Using a few semi-structured questions lessened the second perceived problem. Having student teachers and classroom assistants conduct some of my interviews helped to alleviate pupils from giving answers they think I would like to hear, whilst reducing interview bias. They also acted as gatekeepers by checking the responses I received, thus helping to maintain the trustworthiness of the data (Lincoln and Guba 1985). The aim of trustworthiness, according to Lincoln & Guba (1985 p.290), is to support the argument that my findings are worthy of attention, by ensuring they are credible and represent a realistic interpretation of the interviews I have undertaken. Lincoln & Guba (1985) recommended having research participants review findings to enhance trustworthiness. However, many of my interviews were with young learners who were not able to understand the concepts of my findings, and some of the teachers who I interviewed worked at different schools and may prove difficult to contact, or willing to give up time to analyse my findings. I chose to use the experience and knowledge of my research supervisors to monitor my analysis of the data.

A further issue has been time. With one hour lessons and numerous groups, not to mention classroom management issues, I only afforded ten minutes maximum to each interview, which was part of my reasoning for having so few questions.

Whilst conducting interviews and analysing the data, I could never be sure I had reached theoretical saturation, whereby no new or relevant data, or categories of data emerged to any of my interview questions (Cohen Manion and Morrison 2000). I was constrained in that I had limited numbers of students and teachers to interview, and I could not be certain that different interviewees would produce different, relevant data.

3.8.2 The Semi-structured interview

The semi-structured pupil interviews were designed to respond to research questions one three and four, and contained a number of pre-prepared questions. Appendix 4 shows the semi-structured interview sheet I used with groups of pupils. Appendix 5 shows three completed interview sheets.

The interviews were conducted in the classroom, during lessons, whilst pupils were engaged in written work. I invited small groups of, on average three or four pupils, to come to a corner of the room, away from the rest of the group, where they could sit round a table and I, or a classroom assistant or student teacher, where available, could interview them, in relative confidentiality from their peers. The interviewer recorded pupil responses by writing their answers on an interview sheet (appendices 5-6). Each interview lasted, on average, between ten and 15 minutes. Using small group of interviewees was useful for generating broad data and gathering insights, as Crabtree, Yanoshik, Miller, and O'Connor in Morgan (1993) pointed out. I gave an explanation of assured anonymity and confidentiality for the participants, including that their names would not be recorded, and that their answers would aid my research. Pupils were given the option of whether to participate or not. In terms of informed consent, the school, and myself as a teacher, have 'in loco parentis' care over the pupils. I used my professional judgement to determine the suitability of the questions I used, and the school consented to my gathering of data. I integrated the interviews with normal classroom work where the gathering of data is a part of the assessment processes, though in this case, it contributed to my research. In classes where I worked with a teaching assistant or a student teacher I asked them to carry out some of the interviews, in the same way that I did, order to reduce any bias in my questioning, and to act as gatekeepers by checking the suitability of the questions I wanted answering (Lincoln and Guba 1985). Section 3.10 contains further details about the ethics of my research.

Each question related loosely to a particular research question:

Question 1: **'What do you think about coursework in Science?'** related to research question one and aimed to initiate group discussion which would reveal the perceptions and attitudes of pupils to coursework.

Question 2: **'Do you do better at coursework or exams?'** related to research questions one and two. It is a closed question and was designed to ascertain whether pupils perceived that they were better at one form of assessment than the other. I then compared their views with the quantitative data concerning coursework and examination results, to determine any differences between them.

Question 3: **'How do you learn best in science?'** was an open-ended question, and allowed pupils to explore what they perceived to be good learning experiences. Did they learn for example through group work, through experiments, or by individually answering questions? I aimed to get a general indication of what pupils perceive to be their learning methods in science which could then be related to research question three.

Question 4: **'Do you learn more by doing coursework or theory for exams?'** was connected to research question four and provided a link to the answers expressed in question three. Did pupils perceive coursework to provide a better learning experience rather than perhaps better grades? Is this important?

Question 5: **'Are you able to complete your coursework to targets and assess it as you go?'** was related to research question three and allowed pupils to reflect on what extent they were able to use assessment for learning, in terms of using self, peer and teacher assessment and feedback, to improve their work (section 2.5.4) and active learning in completing their coursework. This question replaced 'Any other thoughts' on the 2005/6 version of the questionnaires to give more of a pupil viewpoint to AfL and how they learned through it.

3.8.3 Teacher interview

Teachers' attitudes to science have come under scrutiny from the House of Lords select committee (2006). They concentrated on how teachers often lacked the confidence and expertise to use coursework. My interviews were designed to ascertain their attitudes and perceptions towards learning by exams and coursework, in order to respond to research questions one to four.

For interviewing professional colleagues I again used a short set of questions. This, as with interviewing children, was due to time being a limiting factor. My colleagues and I did not have much time to sit and discuss coursework. The interviews were conducted in June, during the summer terms, when coursework teaching and marking for year eleven was over. Teachers then had the experience of recently teaching a year of coursework fresh in their minds. Anonymity of answers and confidentiality was explained to all participants, as was the purpose of my research (see section 3.10). The interviews were conducted one to one, and each lasted approximately fifteen minutes. I trialled the questions once, and after ascertaining that they were of a suitable time, length, and level, I used them, with additions in 2006/7, for all of my interviews. All of the teachers I interviewed were delivering the AQA specification. I conducted 23 interviews, 19 at the main school of this study, supplemented by four teachers from other schools, two each in 2006-7, and in 2007-8. As a general rule, a minimum of eight – ten interviews are required to obtain sufficient data (Crabtree, Yanoshik, Miller and O'Connor, in Morgan ed.1993).

Sample interview for teachers are shown in appendices 9-11, and three completed interview sheets in appendix 11.

Question 1: **'How have you found the coursework experience this year in comparison with teaching for exams?'** aimed towards research question one by exploring in a semi structured way and allowing a range of responses about the attitudes and perceptions of teachers to teaching coursework.

Question 2: **'Do you think it (coursework) builds pupil ability?'** helped towards answering research questions two and four by questioning the benefits of coursework in building 'ability'. I left this term open ended to investigate what teachers meant by pupil ability: knowledge of science, ability to undertake independent work, the skills required to write up coursework etc.

Question 3: **'How much help did you end up giving them?'** was designed to test perceptions of how independently pupils learned through coursework. This is linked to research question three and investigating ideas of how children learn through coursework.

Question 4: **'Do you think the coursework deadlines for different subjects should be more spread out?'** aimed to investigate the effectiveness of coursework across a range of subjects where deadlines seemed to fall at the same times, heaping stress on pupils which could in turn lower the effectiveness of coursework, a component of research question four. This question was later posed by the QCA (2007) who cited schools that have policies that coordinate coursework across different subjects to ensure there is no log jam of work for students at such times. I have never worked in such an establishment and I wondered as to how difficult it would be for such a logistical enterprise to be established, especially as many subject specifications were changing or dropping their coursework components. It was interesting to compare colleagues' views on the topic.

Question 5: **'How did you find marking and moderating it?'** aimed at investigating perceptions teachers may have had towards workloads and understanding in coursework marking. Did teachers find it easier or more difficult / time consuming / less effective? The question was open ended to encourage a range of responses. It is another facet of teacher attitudes towards coursework and examinations, which relates to research question one.

Question 6: **'How have you found teaching how science works?'** was added for the 2006-7 interviews to ascertain the extent to which how science works was incorporated into schemes of work, as a response to research question one. As Monk (2006) comments, 'science teachers in England are thinking about how they might strengthen their teaching so *How science works* shines through each and every topic they teach' (p.119).

Question 7: **'Do pupils have much opportunity to use AfL in their coursework?'** was added to the 2006/7 interviews to assess the impact of AfL, in terms of teacher and pupil assessment and feedback, on pupil learning and respond to research question three from a teacher's viewpoint. An objective of AfL, is to give feedback to students so they know how they can improve their work (Moore 2005).

Question 8: **'What use do you make of children's concepts and ideas of science?'** was added for the 2007/8 interview to ascertain the extent to which constructivism is used by teachers, and in particular the elicitation and awareness of prior ideas outlined by Reiss (1993). It helped to find answers for research question three.

Question 9: **'Do exams and or coursework give pupils a meaningful understanding of science?'** was also added in 2007/8 to gauge the extent to which pupils develop an understanding of science through what they learn at school i.e. the experiments and restructuring of ideas they gain through constructivism answering for research question three.

Question 10: **'Do you think they use their science to understand the world outside the lab?'** was the final question, added in 2007/8 to measure whether pupils were able to apply what they have learned through constructivism in science in the application if ideas stage of constructivism (section 2.4.2) described by Reiss (1993). It was aimed to answer research question three.

3.9 Field notes

Field notes have been an important part of this research investigation. As a participant observer, I noted data of interest and relevance to this thesis. Field notes allow for data collection in situ, as Cohen, Manion and Morrison (2000) pointed out. They also allow for accurate interpretation of events and phenomena that outline the bigger picture of events rather than relying totally on questionnaires, interviews and learning observations alone.

I systematically took field notes of observations, viewpoints, opinions and ideas presented by pupils and colleagues who were willing for me to record them anonymously. I dated and coded the comments and sorted them into themes. I used them to support, embellish or question certain theories or ideas from questionnaire, interview and observational analyses, in order to address all of the research questions. They have added depth by providing additional insights as to whether pupils are engaged in meaningful learning through constructivism, and teacher viewpoints on the subject.

Field note observations, however, are open to generic criticisms of qualitative data, namely that they could be subjective or biased, and lacking in quantifiable measures (Cohen, Manion and Morrison 2000).

Table 3.2 Field note codes

Name of code	Explanation
T1,2,3,etc	Teacher
S1,2,3,	School
C1,2,3	Class
P1,2,3	Pupil
05/07	Date of observation
T7S205/07	Example code – teacher no.7 at school no.2: comment made on 5th May 2007

3.10 Field note coding

To ensure the anonymity of the data, and to categorise the information I employed a coding system, as displayed on table 3.2. It shows the speaker or writer, the school they attend, and the date I recorded the observation, which was the day of the comment for spoken observations, but the date of my annotation of written information:

3.11 Observational analysis

In order to respond to research question three: 'how do pupils learn from GCSE assessed science coursework and examination study?' I conducted observational analyses of how pupils learned through coursework and examination lessons. Teachers can gain a lot of information by observing pupils taking part in activities (Littledyke 1998). Observational data added richness to my study by allowing me to see students in a working situation rather than offering opinions. Studying phenomena from more than one standpoint can add richness to data (Cohen, Manion and Morrison 2000) and tables 6.2, 6.4 and 6.6 (chapter six) provide a wealth of data about how pupils studying the different specifications learned through coursework and classwork. Students may work and behave in ways that differ from their spoken and written opinions offered to me. There is less predictability in observations than in interviews, which adds freshness to data (Cohen, Manion and Morrison 2000).

My observational analysis was semi structured (Cohen, Manion and Morrison 2000). This means that the data I obtained was to develop conclusions, particularly for research question three, rather than test a specific hypothesis. I used observation sheets called learning disposition grids to obtain data. The grids were first developed by the EPIC group, an e-learning specialist company (Epic 2006). They allow for observations on how well pupils express themselves, how productive they are, and their innovativeness. This is part of active learning whereby pupils work for themselves. As Capel, Leask and Turner (1995, p.229) wrote, 'a sense of ownership and personal involvement is the key to successful learning'. The learning disposition sheets contain grids, marked on a scale of one to five, where five equals the most productive or expressive, for example, and one the least.

I added a fourth column; constructivism, to ascertain to what extent pupils were engaged in constructive learning via gaining interest in new ideas, the elicitation of new ideas, restructuring or extending their ideas in light of the teacher challenging them, and applying the new ideas via coursework or class work.

I studied how pupils learned through constructivism and active learning by analysing results, field notes and questionnaire data to ascertain their opinions and results in different aspects of science. This was then be related to the different teaching and learning approaches for coursework and exam based study.

I chose a sample of four pupils to observe in each specification. The pupils were selected to give a cross section of abilities within each class and were balanced between boys and girls. I observed the pupils working, or not, over a period of three science lessons, and ranked their behaviour on a scale of one to five, with five being the most engaged and on task, and one being the least. I judged their scores on the quality of work produced, using my professional judgement based on their abilities and what is required at their level of study. I also listened to their responses as they worked and chatted with other pupils and talked to me about their work. The pupils were informed of my observations, and were asked if they objected, using the principle of voluntary informed consent (University of Gloucestershire 2009a).

I judged the constructive learning firstly by gauging the extent to which pupils elicited their own ideas through, for example, brainstorms, memory maps and discussions, and the interest and enthusiasm they showed in doing this. Their ability to restructure and apply their knowledge was measured by, for example, analysing questions and coursework they have written based on new ideas, or measuring their response to practical or plenary sessions based on new scientific ideas.

An example of the Learning Approaches Observation form is included in appendix 6. A form completed by myself as part of the analysis is included in appendix 7.

I did not act as a completely non-interventionalist observer. I completed the learning disposition sheets whilst engaged in teaching classes. I observed pupils working, listening, talking and engaging in schoolwork or non task related activities and made my own judgements as to how their responses corresponded with the learning approaches grid. The pupils were completing group work or I had set a task and was observing the pupils completing it. This had its problems, as I have had limited time to observe and complete the sheets alongside teaching, monitoring and helping pupils. I observed a selection of pupils three times, i.e. in three separate lessons, and averaged the results I uncovered. I analysed pupils in the different science subjects completing both coursework and exam theory to ascertain differences. I observed four pupils in each class, which gave me time to still teach and monitor the learning of the class as a whole. I placed the results for coursework and exam study on the same sheet to show at which points there was a higher degree of engagement. Exam results were colour coded blue, coursework red. I informed pupils that I would be observing their work for my research over a period of lessons and that they would be welcome to see my results if they so wished. None did. The observations I undertook consisted of watching pupils and judging to what extent they achieved different categories of working and learning actively and in groups. The higher the number on the grid, the more continuous and committed the pupils were on this aspect of learning.

A possible downside is that I may have used pupils with specific learning approaches not representative of the whole cohort to observe. I also could have observed more pupils. The observed pupils may not represent the whole sample (Cohen, Manion and Morrison 2000). Time was an important factor in lessons I was teaching and these results, although they are highly context specific, are worthy of extrapolation (Bright 1995). There could also have been subjectivity in my decision making when deciding to what extent my pupils were learning using the EPIC classification. By utilising support assistants and student teachers working with my classes to complete observation sheets, which I have used in conjunction with mine, I strived to lessen the impact of this. Previous events in the school day may affect learning in particular lessons and this could also have affected interview and questionnaire data. There may have been critical incidents: rare but significant and important behaviours displayed by students. This is why varied and rich data over a period of years was taken. The results from these grids do not therefore constitute fixed rules over pupil learning in science but as a guideline to support or act against questionnaire and quantitative data as part of my results analysis and conclusions.

In completing the sheets I was working as an active participant. This means I was a participant with a job to do who is also observing, in order 'to interpret the meaning and experiences of social actors', according to Burgess (1984 p.78). I believed that this was an excellent situation in which to observe as the classes knew and expected me to be in the room teaching them. Therefore, my expected role was to be in the class setting work, maintaining discipline, observing and teaching although not writing about them. This could reduce possible pupil behavioural responses to being observed. A famous example of this was described by Brown and Dowling (1998): 'the Hawthorne effect' (p.39), which followed a study of workers at a company in Hawthorne, USA. In the study, workers' productivity was found to have increased due to being subjects of a research study rather than any factors to do with the research focus.

3.12 Working with children, adults, and ethical issues

It is important to protect participant rights, both adult and children in educational research: researchers must 'protect their participants from undue stress and harm' (Holmes 1989 p.24). These sentiments have been echoed by other researchers, including Cohen and Manion (2000) and Verma and Mallick (1999) and form the basis of the British Educational Research Association (2006) and University of Gloucestershire (2009a) research ethics principles, which I followed. As a classroom teacher, this has always been part of my job, and classroom teachers have the role of parents with the in 'loco parentis' principle whilst working with children. Children rarely give their own consent to participate in fieldwork (Holmes 1989). Homan (2001) described decisions concerning consent being directed at those who make the decisions on behalf of pupils, rather than pupils themselves. Homan (2001) also describes how insider researchers should not be their own gatekeepers. In the case of this research, the school acted as the gatekeeper, allowing me to carry out my research.

Informed consent is essential in educational research (David, Edwards and Alldred 2001, University of Gloucestershire 2009a). The concept of voluntary informed consent applies to pupils and teachers who took part in my research by completing questionnaires or interviews. It was described as 'the condition in which participants understand and agree to their participation without any duress, prior to the research getting underway' (British Educational Research Association 2006 p.6). In addition, the subjects of the research should be informed of what they are to do, and should be able to comprehend the information they have been given free from coercion and undue influence (Homan 1991). Pupils and teachers were told about the reasons for my research, how it may benefit them, and they were given the option not to contribute to my questionnaires and interviews and to withdraw their consent at any time. All opinions, whether they were from children or adults, were treated confidentially and names were never mentioned. Names were also removed from results data and replaced by numbers or letters (Cohen & Manion 1994).

The rights of all participants in research include:

> ... the right to be fully informed about the study's purpose and about the involvement and time required for participation, the right to confidentiality and anonymity, the

> right to ask any questions of the investigator, the right to refuse to participate without any negative ramifications (Morse and Richards 2002 p.205).

It is worth pointing out that adult – child relationships, including those forged in the classroom are 'distinct and lopsided due to gaps in age, physical size and possession of power' (Holmes 1989 p29). This could lead to pupils giving answers to questionnaires (even though they were anonymous, some still put their names on them) or interviews that they think will please me. Holmes (1989) also claims that most researchers involved with children adopt the role of a friend; a role that will gain their trust. I do not have the option of adopting this role. My job gave me a clearly professional relationship with the pupils, which could, accentuate the power differentials that may affect their responses (University of Gloucestershire 2009b).

The data I collected was fully confidential, securely stored, only available to myself, and will be destroyed after five years.

3.13 The internet

The use of the internet in educational research was endorsed by Cohen, Manion and Morrison (2000) who, pointed out how researchers can access cutting edge research from across the academic world. I used it thus to enrich my research and add another dimension to the opinions and ideas I have developed. As Cohen et al. (2000) stated:

> Researchers wishing to gain instantaneous global access to literature and recent developments in research associations can reach Australia, East Asia, the UK and America in a matter of seconds (p.383).

I accessed media articles and government websites, such as the Department for Education and Skills and the Qualification and Curriculum Agency that were relevant to my research to give me up to date information that complemented the books and journals I referenced and were used in the literature review chapter and combined and compared with results data to process the conclusions.

3.14 The research samples

The main school of this study is a secondary school with an approximate pupil population of 1,000 aged from 11-18. It serves part of a small town of approximately 100,000 people and throughout the duration of this study, approximately 40% of pupils achieved five or more A*-C grades at GCSE. The students who took part in this study were aged from 14-16 and studying AQA applied, modular science or science 2006 at the time that they contributed.

Additional data came from one other school where I was permitted to distribute questionnaires. This school taught applied and modular science, and then science 2006 throughout the duration of this study. It contains approximately 1,000 pupils and is roughly the same size as the main case study school. As with the main school of this study, it serves part of the population of a small town of approximately 100,000 people. It was a higher achieving school during the duration of the study, 60% of pupils achieving at least five grade A*-C GCSE, and studying AQA science specifications.

3.15 Summary

'The goal of the researcher is to maximise the capacity for the findings of a specific study' (Gorad and Taylor 2004 p.176). The goals of my study were pursued using a longitudinal study that has allowed me to monitor the change from modular science to applied science and science 2006. Thus, the data was not specific to one time and situation only.

The research involved a case study of a secondary school over three years, consisting of a range of data analyses, bolstered by interview and questionnaire data from other schools. As an employee involved in implementing and working through change, a case study analysis has allowed me to view the school as an example of a system in flux and to ascertain how that change has affected people who work or study there.

The research combined qualitative interviews, observations and questionnaires alongside quantitative statistical methods to progress results and make conclusions that have answered the research questions as a mixed methods study. Combining methods in this way can be 'so powerful in practice', (Gorad and Taylor 2004 p.176). This paradigm of choices was an attempt to answer my research questions from more than one standpoint.

My research combined the interpretive and naturalist methods of questioning and observation with data analysis. Bringing the strands together has given me an overall series of responses to my research questions. Gorad and Taylor (2004) stated that: 'completely different methods can have the same research aim' (p.3). The nature and breadth of my research questions and the complexity of human behaviour demanded this approach.

Using a qualitative approach has given increased validity to the data by establishing that where trends or results in the data are not random or created by chance, it can be stated with a stated level of confidence that significant differences appear to apply. This approach has allowed me to process responses specifically to research questions one and two, in conjunction with qualitative data as a mixed methods study.

The qualitative approach has added validity to the thesis through the honesty, depth, richness and scope of data (Cohen, Manion and Morrison 2000) and the skills and sensitivities of the researcher (Sparkes 1992). By using, and analysing, varied data forms including interviews with pupils and teachers, questionnaires, observational analyses, analysis of results data and filed notes over a period of years I have intertwined findings from each to achieved key findings (chapter nine). Qualitative analysis has given this project a range and depth of rich data in order to analyse and process responses to research questions one, three and four.

Through responding to my research questions, I researched and queried the values, assumptions and policies underpinning teaching and learning in GCSE science. My research can be used to suggest changes, based on empirical results, which can be made in the strategic planning of how, and to whom science is taught.

My positional context in the research was one of a participant observer *in the school*. Cohen, Manion and Morrison (2000) describe participant observation as where 'observers set out to engage in the very activities they set out to observe' (p.186). I had little choice in the matter, having been teaching in the classroom and laboratory whilst observing, interviewing, distributing questionnaires and collecting data concerned with my research questions over a number of years and ascertaining the views of those involved. However, my position was not a participant in the manner some researchers have in becoming almost a member of the groups of students they observe. My position in the school made

this impossible, I observed a large number of students, my observations are a direct result of my position as a teacher, and my data came from colleagues as well as pupils.
The idea of changing and bringing about change also applies to the way I worked and researched. This involved my critically evaluating and improving the research methods I used in order to collect more accurate data to process my conclusions. For example, I added to my pupil interview and questionnaire sheets to gain more information on pupils' views of assessment for learning.

I employed ethical methodologies of data collection to provide evidence for this enquiry. The interview and questionnaire data I collected has been securely stored and any name references have been removed to ensure confidentiality, as Kimmell (1996) recommends. I collected the data acting 'in loco parentis' to pupils (University of Plymouth 2008, University of Gloucestershire 2009a) during normal curriculum activities. In law, children are generally seen as not competent to make decisions until the age of 16 (Southampton University 2008), and institutions such as schools and their teachers act as gatekeepers, making the decisions in the role the parent, including ascertaining the suitability of my questions. Pupils were asked if they would voluntarily fill in the forms. Only I have had direct access to the data. None of my research involved experimentation on pupils, merely observing them studying and asking them about it.

To summarise, I have considered the relevance and appropriateness of the quantitative and qualitative paradigms in research methodology as each are applied to my stated research intention and the epistemology underpinning the focus of my research. I also raised awareness of the issues involved in research with children and the ethics of research. Having justified my methods, the next set of chapters contains an account of the results and inferences I have made from this research. This commences with the pupil questionnaires, followed by pupil interviews, learning approaches observations, teacher interviews, and quantitative analysis.

Chapter 4

Pupil questionnaires

4.1 Introduction

In this chapter I have presented the views of pupils through questionnaires concerning coursework, examinations and assessment for learning. The data have been used to process answers to research questions one to four (section 3.7). Most questionnaire results came from the main school of this study although some have been bolstered by additional evidence from one other school where I was permitted to distribute questionnaires (section 3.14).

I followed the principle of voluntary informed consent (University of Gloucestershire (2009a). Pupils were informed of the nature of my research and given the option of whether to participate. All questionnaires were completed anonymously and the data was available only to me (section 3.12).

The results are presented chronologically. Sample sizes are noted for each set of results. I developed and refined the pupil questionnaire sheet shown in appendix 1 during the 2005-6 academic year, and where opportunity arose I adapted the questionnaire to gain data on relevant points, such as pupils spending a whole day or morning on a piece of coursework or completing their work at an out of school study centre. I have summarised the results for each questionnaire before summarising my overall conclusions. Three examples of completed questionnaires can be found in appendix 3.

4.2 The 2005-6 questionnaire

Responses were given by 76 pupils from two different schools with all pupils in year ten (14-15 years old) in the summer term of 2006. Table 4.1 offers a breakdown of the specifications and the number of boys and girls studying each who responded.

Table 4.1 2005-6 questionnaire respondents

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	10	11	21
Modular science	21	16	37
Separate science	8	10	18
Total	39	37	76

39 respondents were boys, with 37 girls. Ten boys and 12 girls, studying AQA modular science, responded from a school additional to the main case study school (section 3.14).

4.2.1 Results of the 2005-6 questionnaire

Question one: '**I prefer doing coursework to exams?**' found 72% of pupils agreeing a preference to coursework over examinations. The only noticeable differences were that more boys than girls were not sure or disagreed (49%) One girl disagreed compared to eight boys, only three girls were unsure compared to seven boys. Thus 51% of boys agreed with a preference for coursework compared with 89% of girls.

The results for question two: '**I have enjoyed doing the Science coursework?**' show a greater amount of variation between answers, and between the sexes. More girls (32%) claimed to not enjoy the coursework than boys (23%) and 54% of girls were unsure if they had enjoyed it. Other respondents, both boys and girls, expressed similar sentiments. More boys than girls agreed that they had enjoyed it even though they made up only 41% of the total male response, and 13% of the female response.

For question three, '**I work hard in coursework lessons?**' more girls than boys were unsure: 51% and 38% respectively, and more boys agreed that they did work hard: 51% compared to 43%. More boys tended to disagree: 10% compared with 5% of girls

With question four, '**I get stressed about coursework?**' more pupils liked to think that they did not find coursework a stressful experience although more girls were unsure than boys: 35% compared to 17%. However, more boys than girls thought that they did not get stressed: 54% compared with 27%.

No girls disagreed with question five, **'I get stressed about exams?'** whereas 28% of boys did. 81% of the girl respondents agreed that exams did cause them stress. This compares to 51% of the boys, suggesting that a much lower percentage of boys would appear or admit to feeling exam stress.

Considering that all of the pupils surveyed were studying the coursework based applied science and many of them were taking BTEC and other coursework based qualifications in other subjects, there were large numbers who indicated in question six **'Do you think you get the right amount of coursework in all subjects?'** that they were given adequate levels of coursework. 59% of girls and 43% of boys agreed that they get the correct amount. More boys found their coursework too much: 48% compared to 27% of girls.

The final open-ended question, **'any other comments about coursework?'** produced 17 responses: eleven from boys and six from girls. The boys' responses included eight negative responses. These ranged from 'crap' to 'don't like it', 'too much to do in the set time', 'boring and pointless', 'don't like it', 'too hard' and 'too much'. One was mixed stating that coursework 'can be good / tedious' though he did not expand on what good or tedious coursework entailed. Another mentioned that deadlines were too short. One wrote that 'coursework is better than exams and the final respondent simply put 'fun'.

4.2.2 Analysis of the 2005-6 questionnaire

72% of pupils agreed a preference to coursework over examinations. This agrees with Woodfield et al.'s (2005) analysis where a majority of undergraduates declared a positive preference to coursework over unseen examinations.

32% of girls claimed to not enjoy the coursework compared to 23% of boys. 54% of girls were unsure if they had enjoyed it. Girls were found to be generally more anxious about exams than boys (Rogers and Hallam 2006) and more anxious generally about academic issues (Woodfield, Earl-Novell and Solomon 2005). This anxiousness could contribute to some girls not enjoying coursework, which is backed up with field note evidence:

'we don't like it [coursework] 'cos we're more concerned about it than the boys. The lads don't care' (SC2C14P6 09/06/2008)

51% of boys claimed to work hard at coursework, compared to 43% of girls. Woodfield, Earl-Novell and Solomon's (2005) study found that 'women were more likely to report themselves as working hard or very hard towards their assignments than were their male counterparts' (p.8), which goes against the findings of this question. However, the study also reported that many responses stated that there was no gender difference when discussing academic work rates.

Boys, according to Woodfield, Earl-Novell and Solomon (2005), were more likely to 'indicate comparatively low levels of anxiety about lower work rates' (p.8). The results from this questionnaire indicated that 54% of boys compared to 27% of girls answered that they were not stressed by coursework.

28% of boys and 81% of girls claimed to get stressed by exams. The higher levels of stress in girls would agree with the findings of Woodfield, Earl-Novell and Solomon (2005) who noted a higher degree of anxiety over academic issues amongst women undergraduates. This also concurs with the results of Rogers and Hallam's (2006) tests, in which they found that boys were generally less anxious than girls about exams. Their result was statistically significant at the 0.001 level. These results indicate that this anxiety may start well before university. Woodfield, Earl-Novell and Solomon (2005) report how many 'examphobes' tended to be women under the age of 21 but that 'women were not disproportionately represented within the group' (p.6) and that women made a number of positive comments about examinations.

Two girls' comments to the final open ended question echoed the BBC (2005) headlines about coursework and cheating. One lamented that coursework meant 'copying work' whilst the other wrote that this 'could be cheating'. As Jennings (1992) noted, pupils can copy when they complete the same task. Another comment was simply that 'it is crap'. Two responses mentioned teaching: one writing that coursework is 'not explained well enough by teachers' and another stating that coursework is 'not explained enough'. The final comment bemoaned all coursework from different subjects being set at the same time.

4.3 Whole afternoons / mornings for pieces of coursework 2005-6

This analysis of the views of pupils who have completed their coursework over whole mornings or afternoons, rather than in one hour lessons over a series of weeks has been to provide additional information to respond to research question one: 'what are the perceptions and attitudes of key stage four pupils and teachers towards GCSE science coursework?'.

The questionnaire was given to three classes. Details of the respondents are displayed in table 4.2.

Table 4.2 Whole afternoons / mornings for pieces of coursework 2005-6 questionnaire respondents

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	7	7	14
Modular science	4	5	9
Separate science	8	10	18
Total	19	22	41

The first set of respondents was a class of year 11 pupils in the throes of completing their coursework portfolio. The class was studying applied science and was a set two class of 25 pupils working towards GCSE grades C/D. The second was a smaller class of pupils taking single GCSE award modular science and consisting of 13 students aiming for grades D/E/F. The third class was a year 11 class of 27 pupils in the first year of applied science and aiming for C/D grades. A range of pupils were therefore involved, all who have experience of coursework. The questionnaire was handed out one week after exams week, a week of collapsed timetable where classes had two and a half hour lessons in science designed for completion of coursework. From a total number of 63 participants who completed the questionnaire, I received 41 responses. Bearing in mind absentees who may have accounted for a few non replies, I received answers from approximately two thirds of the total cohort. I am aware that Opie (2004) and Cohen and Manion (1994) consider 30 sets of answers to be the minimum number to start quoting percentages in the results.

However, given the small number of classes that took part in the exams week extended lessons and the number of classes available for me to question I felt this to be a reasonable amount of data. With the small amount of data, I did not break the samples down further into boys and girls answers.

An example of the questionnaire can be found in appendix 2.

Question one related to coursework in general and question number two was specifically aimed at science coursework. Both were aimed at gaining a general consensus on pupil viewpoints on coursework, did they prefer it to exams and did they enjoy doing it in science?

Question three related specifically to the longer lessons pupils have had. The question enquired as to whether pupils preferred to complete the work over a morning or afternoon rather than over a series of lessons.

Questions four and five followed on from the theme of blocked coursework lessons, enquiring if such an approach made the work seem more relevant and interesting.

Question six related to the coursework pupils receive across all subjects and like the first two questions aimed to gain an idea of pupil viewpoints as to whether they received too much coursework.

I finished with an open ended question for pupils to express any other views they have. This was to open up other avenues of interest and allow me to collect some more difficult data.

4.3.1 Results of the whole afternoons / mornings coursework questionnaire 2005-6

For question one, **'I prefer doing coursework to exams?'** 70% of respondents admitted that they preferred coursework to exams, with the other 30% unsure. Not one student disagreed with the statement.

Question two, '**I have enjoyed doing the Science coursework?**' produced a far more mixed response with 58% of the pupils unsure if they actually enjoyed their coursework and 29% not enjoying doing it.

Again, over half of the respondents (53%) to question three, '**I prefer doing coursework over a day e.g. at during exams week than over a series of lessons?**' felt unsure of their answer to this question although over a third agreed with the statement and only 10% disagreed.

Just over half of the students (51%) agreed with question four, '**Coursework over a day or morning is more interesting than in a series of 1 hour lessons?**' However 36% felt unsure.

More pupils answering question five, '**The coursework in exams week was more relevant than coursework done over many 1 hour lessons?**' felt unsure of their answers (56%) than agreed with the statement (39%).

The answer to question six, '**Do you think you get the right amount of coursework in all subjects?**' found 78% of respondents agreeing that they received the correct amount of coursework. These questions were asked to applied and modular science students, and they all felt they received enough coursework, despite applied science having far higher coursework content than modular science.

15% of respondents added comments to the final question '**Any other comments?**'. One comment was 'we do too much' and two more positive comments were 'helps you towards GCSEs' and 'teachers can help you'. The three other comments were 'boring' (2) and 'crap'.

4.3.2 Analysis of the whole afternoons / mornings for pieces of coursework questionnaire 2005-6

70% of students preferred coursework to exams, 30% were unsure and none disagreed. The previous questionnaires produced similar results. This indicates a preference for coursework by many pupils.

58% of pupils were unsure, and 29% did not like completing the coursework. Medawar (1982) commented on how science sometimes 'unweaves the rainbow and makes a dull ordinariness out of everyday things' (p.43). This shows some slight differences to my previous research where more pupils agreed (44%) that they enjoyed coursework than were unsure (30%) or disagreed (26%). Bishop et al. (1997) thought there was a correlation between coursework enjoyment and motivation, describing that coursework is motivating and 'provides a challenge for pupils of all abilities' (p.308).

51% of students thought completing coursework in a day was more interesting than completing it over a series of weeks. This could indicate that the interest and momentum gained in a day of coursework may be easier to maintain than going back to the same piece of work week after week. Added to this, less than ten percent of students disagreed that completing coursework over a day is preferable to completing it over a series of lessons. This is despite more than half of the respondents not agreeing that whole days of coursework were better than over a series of lessons.

4.4 Overall analysis of 2005/6 questionnaires

In 2005/6, many boys and girls preferred coursework to exams. There may have been a perception that coursework was easier to improve, and get high marks in pre science 2006 days. Indeed, a 'high motivation amongst pupils doing investigations' was reported by (Gott and Duggan 1995 pp.60-61) and Bishop, Bullock, Martin and Thompson (1997) found that 'the majority of pupils perceive coursework to be an essential part of the GCSE (p.308). The 'learning expectations that affect pupil performance' were discussed by Simon and Jones (1992). This refers to what a pupil expects to learn. Pupils may prefer coursework to examinations because they expect to learn new facts and concepts or because they expect to get the 'right answer' that will get them good marks and in the end a GCSE pass. Coursework can be a learning experience or a means to an end.

Many pupils were not sure if they like doing coursework, with more girls not enjoying it. Some pupils worked hard and got stressed by coursework, with more girls getting stressed by coursework than boys, which could contribute to their not enjoying it. This concurs with similar results in research by Woodfield, Earl-Novell and Solomon (2005) and Rogers and Hallam (2006). Doing coursework in a day produced significantly better coursework grades, and some pupils found this work to be more interesting and relevant than coursework over a series of weeks.

4.5 The 2006-7 questionnaire

This was given to a total of 110 pupils, and 102 responses were received. Details of the respondents are displayed on table 4.3.

Table 4.3 2006-7 questionnaire respondents

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	21	25	46
Separate science	12	16	28
Science 2006	15	13	28
Total	48	54	102

From this total, 46 were taking applied science, 28 the separate sciences and 28 studied science 2006. In total, there were 54 girls, and 48 boys. The questionnaire was given to pupils in the main school of this study. The data was collected in the spring term of 2007.

4.5.1 Results of the 2006-7 questionnaire

Question 1 **'I prefer doing coursework to exams?'** found that 52% of pupils agreed with eighteen unsure and nineteen disagreeing. The difference was most marked in applied science where 73% of pupils expressed agreement, whereas with separate sciences 53% agreed. So the specification with a heavier coursework bias gave a greater degree of preference towards coursework study.

The answers to question 2 **'I have enjoyed doing the Science coursework?'** provided similar numbers of applied students of both sexes agreeing, unsure and disagreeing. More separate subject students were unsure (57%) than any other response and there were slightly more science 2006 students disagreeing. Overall, slightly more students (36%) were unsure than agreed or disagreed (both 28%). This ties in with the 2005-6 questionnaire results. Despite a general enthusiasm for coursework, pupils were not sure they enjoyed the process.

For question 3 **'I work hard in coursework lessons?'** more boys and girls tended to agree, with 52% giving such answers, compared to 38% unsure and 8% disagreeing. The applied and science 2006 results mirrored this trend but not so the separate science students, 64% of whom gave unsure answers, 36% agreed and none disagreed. Exactly half of the students surveyed (50%) thought that they worked hard in science coursework lessons with slightly more girls (52%) than boys (48%) agreeing with this, which concurs with the 2005-6 questionnaire result.

There was less agreement in the answers for question 4 **'I get stressed about coursework?'** A large number agreed (41%) with slightly more girls amongst them, a similarly large number disagreed (37%) including 34% of boys and 44% of girls. 24% were unsure. This differed from the previous year's results where more pupils, particularly boys disagreed although this was not proven to be significantly different. Within the specifications science 2006 students were more inclined to disagree, there were similar numbers of separate science students plumping for either answer and far more applied students agreed than disagreed or were unsure.

For question 5 **'I get stressed about exams?'** 64% agreed, 18% were unsure and 22% disagreed. 73% of girls agreed, and 51% of boys. It is worth noting that more pupils thought they got stressed about exams than coursework so what effect could this stress have on their ability to learn? Separate science students were the least enthusiastic with as many equally unsure or disagreeing as agreeing.

For question 6 **'Do you think you get the right amount of coursework in all subjects?'** more pupils believed they got the right amount with 61% answering thus and 32% thought they had too much. Only 5% thought they had too little. The results were similar in the previous year but with less discrepancy between 'the right amount' and 'too much'. Pupils, some doing large volumes of coursework, therefore had again indicated that many of them received the right amount of coursework despite government drives in the autumn of 2006 to reduce it and remove it from some subjects as AQA (2007) pointed out. This result disagrees with Bishop, Bullock, Martin and Thompson's (1997) assertion that pupils were overloaded with coursework, perhaps due to the phasing out or reduction in the amounts of coursework in many subjects between 1997 and 2007 (BBC 2006b, QCA 2006f).

For the final question 'Are you able to tell what grade your coursework is at and how to improve it?' 50% indicated that they were unsure. 35% answered 'yes' and only 18% 'no'. There were few differences between boys and girls answers, but there were some between specifications. Nearly as many applied science students said 'yes' as unsure (41% compared to 43%) but with science 2006 only 21% said 'yes' and 57% were 'unsure'. Separate science students responded with 'unsure' (57%) or 'yes (39%). There was only one 'no'.

Other comments included four applied students writing that they needed more help, three science 2006 students expressing a preference for exams two separate science students bemoaning the theory they miss out on by doing coursework.

4.5.2 Analysis of the 2006-7 questionnaire

There were similar responses 2005-6 and 2006-7, showing that opinions remain, despite the changes in specifications.

Pupils still tended to prefer coursework to exams. This was more pronounced in applied science and less pronounced in science 2006 and the separate sciences where coursework constituted less of the total mark. They were not sure if they like doing coursework yet they worked quite hard and got stressed by it, but not as much as they did for exams. However, there were few differences between boys and girls results for these questions. Pupils of both sexes with more coursework tended to get more stressed about it.

More girls indicated they found examinations stressful. This concurs with the result from the previous year, and provides more evidence that girls indicate they feel more exam stress.

Many pupils felt that they received enough coursework in all specifications. They were not generally sure if they could apply assessment for learning techniques to improve their grades, especially science 2006 students who did their coursework as short practical sessions and tests and could only take on board their mistakes from previous attempts to improve next time. Applied science students with their high volume of coursework tended to be more confident at assessing and improving on it, perhaps as they had far more opportunity to do so. McDonald and Bould (2003) discovered a positive response to students developing their own assessment. Within this, self assessment allowed 98% of them to improve their study habits. Many students in this study were unsure if they could self assess.

4.6 The 2007-8 questionnaire

Only in 2007/8 could pupils opt for an applied or a science 2006 approach in their final year. Thus they could opt for a higher or lower level of coursework. Table 4.4 shows the number of students from different specifications that completed the questionnaire.

Table 4.4 2007-8 questionnaire respondents

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	14	24	38
Separate science	9	9	18
Science 2006	22	33	55
Total	46	65	111

The questionnaire was completed by a total of 111 pupils in the spring term of 2007/8 from a total of 122 distributed. Within that number there were 18 responses from separate science students, 38 from those studying applied science and 55 from science 2006 pupils. Boys accounted for 46 responses, with 65 from girls.

4.6.1 Results of the 2007-8 questionnaire

For Question 1 '**I prefer doing coursework to exams?**' I found some agreement with the statement, as with previous years. In total, 62% of pupils expressed a preference for coursework over examinations, which is lower than 2005/6 (72%). There were few differences between boys and girls views, although there were some differences between the subjects. Applied science pupils were most in agreement with coursework, with 78%

in favour. Separate science students were 61% in favour whereas 51% of science 2006 students agreed with the statement.

The answers to question 2 '**I have enjoyed doing the Science coursework?**' showed disparity amongst the sexes. More boys in each specification disagreed with the question, and more girls were likely to be unsure. Overall, more girls agreed and the difference was more marked in science 2006 than in the other specifications. Overall, more pupils were unsure (43%) than agree (28%) or disagree (29%). This is similar to the results in 2006/7. More applied science students were unsure than in 2005/6 and 2006/7. As with the previous year, more separate science students were unsure proportionally than the other specifications and more science 2006 students disagreed than the other specifications. Therefore, as with the responses to this question in previous years, pupils were unsure if they like doing coursework, despite preferring doing it to exams.

In answering question 3 '**I work hard in coursework lessons?**' 51% of boys and girls pupils tended to agree with the statement, concurring with the results of the previous two years. As with 2006/7 a very slight majority of applied (58%) and science 2006 pupils (51%) agreed with the statement, Separate science students were less sure, with 50% agreeing and 42% unsure. This is an improvement on the previous year where considerably more pupils were unsure than agreed. Overall, only just over half of the pupils questioned (53%) agreed that they worked hard to complete their coursework.

Question 4 '**I get stressed about coursework?**' showed 40% agreement with the statement, drawing parallels with the 2006/7 result, which was 41%. More girls (47%) than boys (32%) tended to agree in all specifications. 30% of all pupils disagreed, a lower number than the previous year, and 28% were unsure. Between the specifications, applied students were more likely to agree with the statement with 66% doing so. There were as many disagreeing as agreeing in the separate sciences, as with previous years. Science 2006 students were most unsure with slightly more choosing this answer than for agree or disagree which had similar numbers.

For question 5 '**I get stressed about exams?**' a slight majority of 58% agreed. 17% were unsure and 22% disagreed. 69% of girls agreed as did 49% of boys. Science 2006 students were the least enthusiastic 32% disagreeing compared to 49% agreeing. It is worth noting that again more pupils thought they got stressed about exams than coursework. Stress reduces the ability of the brain to think beyond 'flight or fight' reactions and this could affect the ability to learn (Levine 1997).

Question 6 **'Do you think you get the right amount of coursework in all subjects?'** gave a similar set of answers. Most pupils were unsure (64%), with 28% disagreeing and only 7% agreeing. There were only negligible differences between boys and girls and between different specifications. This differs from the previous years when most pupils agreed with the statement. This shows a significant shift, with pupils taking all specifications becoming less sure that they receive adequate coursework at a time when coursework was being reduced or phased out of some subjects.

The final question **'Are you able to tell what grade your coursework is at and how to improve it?'** was answered as unsure by 46% of pupils, which was similar to the 50% in 2006/7. 20% agreed, which was lower than the 35% the previous year, showing slightly fewer pupils were confident of being able to assess and improve their work. This could be due to science 2006 coursework, which cannot be improved over time. Just under half of the students who completed this survey (49%) studied science 2006. However there were similar results for all of the specifications and few differences between boys' and girls' views.

Other comments included four pupils deriding coursework, and one describing it as hard. One separate science student explained that they preferred exams, yet two applied pupils gave the reverse opinion. Science 2006 students' comments included the need to make coursework funnier, or more creative. One student described how they need to feel confident in order to complete their coursework.

4.6.2 Analysis of the 2007-8 questionnaire

The 2007/8 questionnaire results showed consistency with those of previous years. With specifications changing across the duration of this study, views have tended to remain constant, with the exception of question six where in 2007/8 pupils have tended to be unsure, rather than agree that they get enough coursework.

Pupils tended to prefer coursework to exams. As in previous years the subject with the most coursework, applied science, had most pupils in favour of a coursework based approach. In a survey in Northern Irish schools, 85% of pupils were positive about investigative work (Jones, Gott and Jarman 2000). Science 2006, with a newer form of coursework, showed fewer pupils, at 51%, preferred a coursework based approach.

Many pupils were unsure if they liked doing coursework, yet they worked quite hard and get stressed by it. It would appear as in 2006/7 that, in general, pupils who have more coursework got more stressed about it, and that science 2006 students were unsure about the stress induced by their new course.

Girls tended to be more stressed by exams than boys. This is consistent with Rogers and Hallam's (2006) finding that boys were significantly less anxious about exams.

Most pupils got enough coursework in all specifications, until 2007/8 when two thirds were unsure that they received the right amount of coursework. Just under half of the pupils were unsure if they could apply assessment for learning techniques to improve their grades. Only 20% felt that they could assess and improve their work.

4.7 Overall conclusions

After three years of questionnaire results from applied, modular and separate science students, I have been able to conclude that in this study:

- Most pupils, studying all specifications, preferred coursework to examinations
- Most pupils were unsure if they liked a coursework based approach
- Pupils tended to get more stressed by examinations than by coursework
- Girls tended to get more stressed than boys about coursework, and particularly about examinations
- A majority of pupils were unsure if they could use AfL to improve their coursework

These conclusions were consistent throughout the three years of the study.

Taking each conclusion in turn, it would seem, firstly, that coursework was a popular component of all specifications of science GCSE. The investigative component of coursework could be a reason for this popularity: In a survey where 118 pupils in 30 Northern Irish schools were interviewed, 85% of pupils were positive about enjoying investigative work (Jones, Gott and Jarman 2000). Another reason for this could be that coursework gives pupils a grade that they can improve on so that they know that they have some marks secured before their examinations. In terms of boys and girls, there were few differences in viewpoints. Rogers and Hallam (2006) had similar results to their questionnaire, pointing out that their result is 'contrary to suggestions that boys are less than conscientious, lack the necessary organization, and planning skills and are insufficiently motivated to do well in relation to coursework' (Rogers and Hallam 2006 p.68).

This seems at odds with the responses given about a coursework based approach. Perhaps coursework was the lesser of two evils for many pupils: better than revision for examinations, but still hard work.

The concept of examinations where pupils must sit for an hour or more and think induced more stress than coursework, which when planned and taught properly could be completed over a month or more for applied or modular specifications. Science 2006 coursework is completed in a number of set classroom sessions and cannot be improved afterwards. Pupils studying the specification in 2007/8 were more likely to disagree that they preferred a coursework based approach than those studying other specifications.

There was some agreement across specifications in 2005/6 (mornings and afternoons) and 2006/7 that pupils received the correct amount of coursework. Perhaps some pupils accepted the level of coursework on the specifications they were given and merely got on with completing it. Only in 2007/8 could pupils opt for an applied or a science 2006 approach in their final year. Thus they could opt for a higher or lower level of coursework. The results in 2007/8 showed that pupils who opted for their specification were also less sure that they received the correct amount of coursework, unlike in previous years where many students indicated that they received the correct amount.

Field note evidence from one applied science pupil revealed that they were worried about time constraints:

> 'I work harder for coursework than exams definitely but I wish I had more time to do it' [coursework], it is all in a rush now' (S1C2P2 12/05/2007)

Another complained about the volume of coursework across all subjects:

> 'You aint got time to revise, you've got loads of coursework to do for all other subjects' (S1C3P7 18/04/2007)

Time management may have been an issue here for these students. From my experience, many students at GCSE level are not effective at managing time effectively, and sometimes struggle to meet coursework deadlines. An applied science student in the 2006/7 interviews (section 5.6) complained of not having time to complete their coursework.

Over ninety percent of students agreed that completing coursework over a day is preferable to completing it over a series of lessons.

Additional field note evidence from asking pupils what they have found relevant from their science coursework shows that some applied science students had different ideas:

> 'I haven't learned much from science' (S1C4S17 19/04/2006)

> 'How to make beer?' (S1C4S2 19/04/2006)

> 'Oh yeah, that's one thing, I'll brew my own cider' (S1C4S17 19/04/2006)

This referred to an applied science project where the growth of yeast was monitored in the brewing process but it demonstrates some of the things pupils remembered from their science education.

Others were less sure, believing that science was not of any relevance to them:

> 'I don't exactly use science for everyday things, do I?' (S1C4S11 09/05/2007)

> 'I've learned only this: Don't stick metal in a microwave or don't stick wet fingers in plug sockets' (S1C5P26 20/05/2007)

Thus the relevance of GCSE science may differ according to the interests of, and the constructs built up by, individual learners.

Results from the three years seem to confirm that in the school of this study, girls generally got more stressed by coursework, and particularly by examinations:

More girls (47%) than boys (32%) in 2007/8 agreed they were stressed by coursework. This compares with 34% of boys and 44% of girls in 2005/6.

73% of girls agreed, and 51% of boys agreed they got stressed by exams in 2006/7. In 2007/8 69% of girls agreed, as did 49% of boys.

These results concur with research by Woodfield, Earl-Novell and Solomon (2005) about academic stress, and Rogers and Hallam (2006) concerning anxiety and examinations. This could be due to many girls being more honest in their views of stress than their male counterparts, or real evidence that they do generally get more stressed more, particularly in examinations where the stress is concentrated, rather than spread out over pieces of coursework, although field note evidence (section 4.2.2) indicates that some girls are more anxious than boys about coursework.

Assessment for learning was not something all pupils could use to improve their coursework. 46% of pupils in 2007/8 were unsure if they could assess and improve their work, as did 50% in 2006/7. 20% agreed that they could assess and improve their work in 2007/8, as did 35% in the previous year.

Appendix 12 shows an improvement sheet that pupils have been able to use to improve their work against specification standards based on teacher assessments of their work. It could be that some pupils were used to teachers giving them help and pointers to improve their work, rather than assessing it themselves.

Field note questioning, asking whether pupils used improvement sheets, found that some pupils preferred this approach:

> 'I'd use the improvement sheets [upon which teachers and pupils write down what the pupil needs to do to improve the piece of work] every time to get it [coursework] marked, take it back and make it better, that way I know what I'm going to get' (S1C2P7 02/05/2007)

Teachers opined that in some cases they had to assist pupils a great deal (section 7.3 question 3). Such an approach may have inhibited some pupils from thinking for themselves. However, relatively few pupils indicated that they could not assess their coursework for improvements, which indicates that most pupils have been doing it to some extent. There was though, not the positive response to assessment for learning described in McDonald and Bould's (2003) study of learners in Barbados. They found many students espousing how AfL made them analytical critical, independent, and empowered. However, their study was carried out in a different setting to the UK education system, on an island of a quarter of a million people, where significant training was offered to those pupils taking part in self assessment. This was not the case for pupils in this study, and the lack of training may be a reason for their less positive response to using AfL for science coursework.

Woodfield, Earl-Novell and Solomon's (2005) study on male and female coursework attainment at university level found that:

> Students of both sexes claimed they believed coursework to be a fairer measure of actual educational achievement as it tested their knowledge and broad analytical abilities better than examinations, which they felt primarily tested their powers of recall and their ability to withstand extreme pressure (p.41).

This has similarities with my findings from my GCSE coursework in a day questionnaires where 71% of respondents preferred coursework to examinations and not one response expressed a preference for exams.

Aside from the 2005/6 questionnaires, no pupils mentioned cheating and coursework. Two pupils in that year wrote of cheating equating to 'copying work' whilst the other wrote that copying 'could be cheating'.

In terms of sample size, there has been some degree of variation. As the main school of this study has grown, this has been reflected in increasing student numbers through the three years of the study. In the first year of questionnaires, 76 responses were received. This compares with 102 and 111 in the following years. Smaller sample sizes are likely to have an increased chance of error, where the views of respondents do not match those of the population, according to Cohen, Manion and Morrison (2000), who described a table of sample size needed against population size. They argued that, for a population size of 120, 92 respondents would be needed to give meaningful data. In 2005/6 the total population size was 126 and 76 questionnaires were completed. In 2006/7, 102 questionnaires were completed from a population size of 134, with a minimum of 100 needed. In 2007/8, 111 questionnaires came from a population of 218, with 140 needed. Therefore, two thirds of my sample sizes fell below Cohen, Manion and Morrison's (2000) recommended minimum. However, such recommendations are 'a rather simplistic and quite possibly conservative method for ascertaining a sample size' (Powell 1979). As a general rule, using as large a sample as possible will give more reliable and meaningful data (Powell 1979), which I have done by distributing questionnaires to as many students as I was able to.

In this chapter I have analysed a considerable array of data concerning pupil views of coursework and exam based studies, in order to respond to research questions one to four. In the forthcoming chapter, I have added pupil interview data, supported by field notes, in order to build on my response to the four research questions.

Chapter 5

Pupil interviews

5.1 Introduction

In this chapter I have used interviews with small groups of pupils in order to ascertain their views about coursework, examinations, assessment for learning and learning in science. The interviews spanned the three years of this research and I have presented the data and conclusions chronologically supplementing evidence with field notes when required, with an overall conclusion to sum up the findings. The data and findings from this section were instrumental in answering research questions one, two three and four. All interviews were conducted with GCSE science students aged 14-16 in the main case study school of this study. The interviewees were assured of anonymity, a fundamental right of all participants involved in research (Morse and Richards 2002). The principle of voluntary informed consent was adhered to (University of Gloucestershire 2009a). Pupils were informed of the nature of my research and given the option of whether or not to participate.

I did not break the sample down by gender, as the interview data provides overall evidence of pupil views, rather than a gender based one, evidence of which is provided in chapters four and eight. Examples of three completed interview sheets can be found in appendix 5.

5.2 Pupil interviews 2005-6

For both science disciplines I interviewed five sets of pupils with a total of 29 pupils, including 15 modular and 14 applied pupils. Not all pupils offered a range of responses but all contributed in some way; hence the total number of responses does not always add up to the number of pupils interviewed. Table 5.2 shows the number of participants from different subjects.

Table 5.1 2005-6 Interview respondents

Subject	Total number of pupils
Applied science	14
Modular science	15
Total	29

The overall impression I gained from interviewing GCSE pupils was that they were pleased to be interviewed and pleased that their views of how they learned in science were being considered. The interviews, using the template documented in Appendix 4, were completed in April in the early part of the summer term of 2006, to allow year 11 pupils to have their say before departing for exam leave. As Fullan (1991 p.70) pondered, 'what would happen if we treated the student as someone whose opinion mattered?'

5.3 Results of the pupil interviews 2005-6

For question one '**What do you think about coursework in Science?**' there was some disparity in viewpoints. There was no agreement on what pupils think of science coursework. Some applied pupils had a negative opinion of coursework e.g. 'it's really bad'. Those studying modular tended to be more positive, with comments such as:

> 'It is easy to do the coursework; we work with odd results to get conclusions'

Question two '**Do you do better at coursework or exams?**' shows some differences in views with many modular pupils who answered opining that they did better at exams e.g. 'I find I get better results in exams'. Amongst applied students were some who preferred coursework:

> 'Coursework, coursework, coursework for me, it is less stressful than exams'

For question three '**How do you learn best in science?**' some modular students preferred to learn via revision at home, taking responsibility for their learning. This was the most popular answer for question three; with answers such as 'I'd rather revise by myself at home'. Practical work, but not coursework, was popular with modular pupils with responses including 'I like doing experiments best'. One group of applied students preferred coursework and practical sessions whereas others indicated that they learned best through coursework.

Question four '**Do you learn more by doing coursework or theory for exams?**' found some modular pupils claiming to learn by coursework whilst others were unsure:

> 'I learn better doing theory for exams...and coursework too, I learn through both'

Many applied science students saying that they learned more by coursework with answers including:

> 'I much prefer to work by myself or with friends on the coursework than doing revision for exams. You know what mark you'll get for it'

Question five **'Any other thoughts?'** failed to provide any further insights. Students were either reluctant to add any further thoughts, or did not have any other ideas or opinions to add.

5.4 Analysis of pupil interviews 2005-6

The disparity of views found in answers to question one are despite questionnaire evidence (chapter 4) that many pupils studying all specifications preferred coursework to examinations, and that in the 2006/7 questionnaire, 73% of applied science pupils expressed a preference for coursework (section 4.6). However in interviews, some applied science students were negative about their coursework. Others claimed to learn more through coursework, with one learner comparing this with the stress they felt about exams. Many other pupils simply found coursework 'ok' or 'good' without wishing to explain why. Some modular students questioned expressed a preference for learning through coursework. Others expressed a preference for examinations in terms of doing better, but they claimed to learn more through coursework. Gibbs and Simpson's (2004) found that undergraduates were more likely to remember what they had learned through coursework than examinations, and in some of the interviews, a similar pattern may have emerged.

Research by Jones, Gott and Jarman (2000) and Murray and Reiss (2005) found practical work to be popular with students. Some pupils in the 2005/6 interviews also expressed a preference for learning through practical work. Others preferred revising at home or completing coursework, reflecting a range of learning styles that pupils employ.

5.5 Pupil interviews 2006-7

As with the previous year, the interviews were conducted in April, in the early summer term. 70 pupils offered their opinions; 28 studying applied science and 27 taking the newer science 2006 course. The final 15 studied the separate sciences. These are detailed in table 5.2.

Table 5.2 2006-7 Interview respondents

Subject	Total number of pupils
Applied science	28
Separate science	15
Science 2006	27
Total	70

The categories of response were determined by the answers the students gave, thus they were determining their opinions within the framework of the questions. Again the pupils were happy to be asked their opinions. No pupils declined to answer any questions. For this year and for 2007/8 the final question '**Any other thoughts**' was changed to '**Are you able to complete your coursework to targets and assess it as you go**'. This was to enable the collection of data concerning whether pupils thought they could use assessment for learning, in terms of peer, self and teacher assessment, for their coursework, and whether they were able to learn actively whilst completing it. This provided data to respond to research question three: 'how do pupils learn from GCSE science coursework and examination study?'.

5.6 Results of the pupil interviews 2006-7

For question one '**What do you think about coursework in Science?**' many students across the specifications described coursework as 'ok' or 'bad'. Some science 2006 students had a negative view of it with opinions such as 'it's bad, I don't like it', without expanding upon why. One compared coursework to exams, stating that:

> 'It is not good doing the coursework. It is like exams, but exams are better. They are worth more'

Separate science students tended to offer a range of views, including 'easier to get marks in', 'writing it is a pain' and 'more pressure'. Applied students were more likely to emphasize that to them coursework is better than exams:

'It [coursework] is better than exams, it is easier and you have more time and more help'

In answering question two '**Do you do better at coursework or exams?**' many pupils across the specifications declared that they achieved more by doing coursework than exam work with sentiments like 'You get a better result as you can get your grades first'. One applied science student was concerned about the volume of coursework they had, stating that:

'I have trouble getting all of the coursework I have done in time'

For question three '**How do you learn best in science?**' there was more divergence in answers. Experimental work was a popular answer, echoing the results of Murray and Reiss (2005), with 'coursework', 'teachers' and even 'don't know' getting a number of answers. Science 2006 students were more likely to answer 'teachers' and 'experiments' whereas applied and offered a range of responses including 'videos', ' I prefer to read textbooks' and 'working alone at home'.

Despite a muted response in terms of positive views of coursework in question one there was some agreement that pupils in all three subjects learned more via coursework with many pupils answering thus for question four '**Do you learn more by doing coursework or theory for exams?**' with answers such as:

'Coursework definitely is how I learn best. I dunno, I just prefer doing it'

For the final question '**Are you able to complete your coursework to targets and assess it as you go?**' many separate and applied science pupils were confident that they could assess their coursework to set targets, and improve it: 'yes I can, definitely' being a sample answer. However, some science 2006 pupils felt they were unable to, or did not know: 'I'm not sure how to do this with targets' was one answer, indicating the nature of the coursework which cannot be improved upon.

5.7 Analysis of pupil interviews 2006-7

The new nature of their coursework, which was completed under exam conditions and could not be improved upon, and the fact that teachers have little experience of teaching it could be two contributing factors to why more science 2006 students had a negative opinion of their coursework than those studying other specifications.

As in 2005/6, there was a wide range of ideas to how pupils learn in science, reflecting the individual nature of how pupils learn. I pointed out from analysing table 2.5 that I believe the reasons for motivation are as individual as each pupil that steps into a science classroom and this may also apply to how pupils learn.

Research by Jones, Gott and Jarman (2000) found 79% of the pupils they questioned thought that they had learned through coursework. Jones, Gott and Jarman (2000) noted procedural understanding – how to plan an experiment, and especially conceptual understanding of the science behind it was what pupils were gaining. Many pupils in these interviews claimed to learn most through coursework.

Many science 2006 pupils felt less able to assess and improve their coursework. The implementation of the coursework this year and the classroom based testing nature of it made it unsuitable for gradual improvement, and this was mirrored in many of the pupil views. Some separate science students were most confident that they could, and this may agree with quantitative evidence (chapter eight) that separate science students tended to achieve significantly better coursework scores than examination throughout the three years of this study.

5.8 Pupil interviews 2007-8

The interviews were conducted early in April, in the summer term, and given to a total of 70 pupils, as shown on table 5.3.

Table 5.3 2007-8 Interview respondents

Subject	Total number of pupils
Applied science	18
Separate science	21
Science 2006	31
Total	70

Of the respondents, 18 studied applied, 31 science 2006 and 21 took separate sciences. As with previous years, the categories of response were determined by pupil answers, and the pupils asked were happy to share their opinions with none declining to comment.

5.9 Results of the pupil interviews 2007-8

Many pupils described their coursework as either 'ok', 'better than exams' or 'not good' for question one **'What do you think about coursework in Science?'**

Many negative responses came from science 2006 students with answers including 'not good'. One complained that 'I really don't like doing the coursework' without expanding on their reasons. Science 2006 pupils were least in favour of coursework over exams in the 2007/8 questionnaire (section 4.7). One group though offered a different opinion:

> 'We think it is good, it helps us to get ready for our exams'

This highlights how the type of coursework used in science 2006, with a written paper in exam conditions can help prepare learners for their examinations.

Many applied science students preferred coursework, with answers such as 'coursework is better than exams'. One group of separate science students said that they had no choice, they had to do coursework.

For question two **'Do you do better at coursework or exams?'** many interviewees, in all specifications, claimed to learn best in science through coursework, a similar result to 2006/7. This included one applied student who added 'coursework...'cos you can improve on it'. A group of science 2006 learners claimed that:

'Coursework...easier and you don't get so nervous [as for exams]'

This is despite the examined nature of that coursework. Two separate science groups mentioned being able to improve their work which is evidence that they were able to use AfL. Statistical evidence (section 8.6) shows that separate science learners in 2007/8 achieved significantly higher coursework than examination scores.

In terms of question three '**How do you learn best in science?**' practical work and experiments were popular choices with students from all specifications responding with answers such 'I like doing the experiments and I learn from them best'. A few were unsure, while there was a range of responses across the specifications including 'We learn best when we do experiments and watch scientific videos'. Other learners mentioned 'class discussions' and 'watching slideshows about the lesson'.

For question four '**Do you learn more by doing coursework or theory for exams?**' there was, as in previous years, a tendency for pupils to say they learned more through coursework than exams. Many applied students were in favour of coursework, with responses including 'coursework definitely, I learn more doing it, I can do it myself'. Separate science students' answers varied between 'coursework', 'examinations', and 'unsure'. Some science 2006 believed that they learned through both: 'we learn through theory and coursework'.

For question five '**Are you able to complete your coursework to targets and assess it as you go?**' many respondents across the specifications agreed that they could complete their coursework to targets and assess the grade they were working at. One separate science group specifically mentioned teacher feedback as a factor in this. A science 2006 group thought that time constraints may hinder this process.

5.10 Analysis of pupil interviews 2007-8

The students who described coursework as good e.g. 'coursework is good, I like doing it' compare with 62% of 2007/8 questionnaire respondents expressing a preference for coursework over exams. In a study in Northern Ireland, 85% of students enjoyed investigative work (Jones, Gott and Jarman 2000).

The science 2006 coursework was not appreciated by some pupils, as they responded negatively to their coursework. Others thought that it was good preparation for their examinations. Some of those who had opted for applied science were positive about the coursework they did, possibly because they preferred this way of learning, which is why they chose applied science.

As in previous years, pupils claimed to learn best through a variety of means. This shows a range of learning styles, with some pupils preferring to learn by listening, and others by visual stimuli or by kinaesthetic means. Also showing similarities to the research in previous years, most pupils claimed to do better through coursework. This compares to the 79% in Jones, Gott and Jarman's (2000) pre applied and science 2006 study who claimed to learn through investigative work.

Many pupils in 2007/8 felt able to assess and improve on their work. Some specifically mentioned teacher feedback in helping them to do this. This is an improvement on the previous year and could point to increased teacher and pupil confidence at using assessment for learning to improve work. This shows a more positive response by some groups than through questionnaires where in 2007/8, 20% agreed, and in 2006/7 35% agreed that they could improve their coursework to targets and assess the grade they were working at.

Many science 2006 students felt they could not assess and improve their work than those studying other specifications. This echoes the results of the previous year and highlights the nature of the coursework, which, although pupils could take practice attempts at doing it, could not be improved gradually using AfL.

5.11 Overall conclusions

According to Jones, Gott and Jarman (2000) 85% of pupils 'gave a very positive response to a question they asked about enjoying investigative work. The results of these interviews did not concur, with many simply describing their coursework as 'ok' or even as 'bad'. Field note evidence from some pupils, who were undertaking coursework investigations in a year ten lesson, corroborates this with comments, such as the following:

'Coursework is ok because we can get all the marks in but it is boring though' (P14C2S1 31/06/06)

'I only improve my work...'cos you make us do it, I don't really care' (S1C7P10 07/06/2007)

'I improve work...sometimes to impress parents so they buy us stuff' (S1C8P23 19/06/2007)

These particular comments pertain to the importance of coursework for the extrinsic goal of obtaining exam grades (Harlen 2004). There is additional evidence for this, as many pupils in all of the years of the interview said that they learned more through coursework than by exams. 'I like coursework much more, you can get your grades first' was an example of a response in 2005/6.

Pupils tended to respond more positively about assessment for learning (in terms of improving their work to peer, self, and teacher assessed standards) through interviews, than in questionnaires. One grouped mentioned teacher feedback in helping them to assess their work. Possibly some pupils felt they needed to present a positive view of AfL to myself as their teacher, as interviews can create an artificial environment where pupils may not express their real feelings according to Holmes (1989). Interview and questionnaire data uncovered less enthusiasm for AfL than McDonald and Bould's (2003) research. Some pupils considered that time constraints affected their ability to improve their work.

Some applied, modular and separate science pupils felt confident in using self, peer and teacher assessment to improve their work (as the QCA (2006d) claimed to be a part of AfL). Many science 2006 students were less confident, which is reflected in the nature of the science 2006 coursework, which cannot be revisited and improved and does not lend itself as well to assessment for learning techniques. It may have led to some science 2006 pupils forming negative views of coursework. Despite having stated that they learned more through coursework, some science 2006 pupils in 2007/8 expressed sentiments such as 'I don't like it, it's hard to do'. Perhaps for these pupils, an opportunity to give them more effective coursework involving AfL has been missed.

Many modular science pupils claimed that they learned best through examinations: 'you can learn all the stuff you need in one go'. However, quantitative evidence (section 8.2.1) suggests that many of them achieved significantly better coursework grades than for examinations.

The views of some separate science pupils, when asked during an exam lesson if they work harder for coursework or exams, would seem to indicate that those asked thought exams to be more important for their overall result:

> 'I hate exams but I work harder 'cos they determine what jobs you get' (S1C3P3 08/06/2007)

> 'Exams are more important so I work harder for them' (S1C3P13 08/06/2007)

Some applied science pupils who were asked when completing coursework thought differently, for example:

> 'Coursework is more important, definitely' (S1C12P12 16/10/2007)

Despite the above, in the 2006/7 and 2007/8 interviews, some separate science students claimed to work harder for coursework than for exams, and statistical evidence (section 8.6) showed that they achieved significantly higher coursework than examination scores. Many applied and science 2006 students were also likely to say they worked best through coursework. So, in some cases those who took more examination based specifications claimed to learn most effectively when studying coursework

Practical work and experiments proved to be popular choices for many pupils when asked how they learned best in science, concurring with research by Jones, Gott and Jarman (2000) and Murray and Reiss (2005). Field note evidence would suggest that some students did not have much practical work in their lessons. When a sample group of students in an examination study lesson was asked if they did enough experimental work, the following answers were forthcoming:

> 'No, do we do *any* experiments is the question' (SC1C14P22 09/10/2007)

'Do we? No' (SC1C14P20 09/10/2007)

Other pupils provided similar responses, pointing to a lack of opportunity to learn through experiments, at least for the pupils I asked.

There was a range of other answers including modular pupils in 2005/6 stating that they learned best via home revision: 'I'd rather revise by myself at home', and separate students in 2007/8: 'I prefer writing up notes in my own words', thus taking responsibility for improving their own knowledge. Other answers included 'teachers', 'experiments', 'videos' 'slideshows' and 'textbooks' indicating a range of learning methods as individual as each learner.

The pupil interview sample size was small in the first year, with responses from 29 students. In the second and third years, 70 students were interviewed. A smaller sample size allows for more detailed analysis (Cohen, Manion and Morrison 2000). There is a risk that variation inherent in the responses of some of the individuals interviewed may have more of a bearing on the overall results in the first year, than they did in the second and third years when the sample size was larger.

Having compiled a wealth of interview and questionnaire, data, in order to develop evidence to respond to research questions one to four, the next chapter is concerned with the observation of pupils at work completing coursework and examination studies. This chapter provides data in order to respond to research question three: 'how do pupils learn from GCSE science coursework and examination study, and what is the role of active learning?'

Chapter 6

Pupil learning approaches

6.1 Introduction

In response to research question three, I observed pupils at work during coursework and exam work lessons over the three years of this study. This chapter documents the averaged results for pupils working at the various specifications. The observations are discussed in chronological order with a conclusion to each year and an overall conclusion summarising what this facet of the research has uncovered. Pupils were informed that I would be observing their work for my research over a period of lessons and that they would be welcome to see my results if they so wished. None did. They were also asked if they objected to being observed, under the principles of voluntary informed consent (David, Edwards and Alldred 2001, University of Gloucestershire 2009a).

I did not break the sample down by gender, as the observation data provides overall evidence of pupil views, rather than a gender based one, evidence of which is provided in chapters four and eight. A sample completed analysis form can be found in appendix 7 and a blank form in appendix 6. How I judged the performance of each student in the different categories can be found in chapter 3.11 Observational analysis.

6.2 Pupils completing science coursework and exam work 2005-6

For the applied science observations, I observed eight pupils from two separate classes as they completed and analysed year ten unit 1 coursework components, and unit two, exam theory for the January 2007 examination, over the space of three lessons in the summer of 2006. The specifications and number of students I observed are detailed on table 6.1.

Table 6.1 2005-6 Observations

Subject	Total number of pupils
Applied science	8
Modular science	4
Total	12

For the modular science set of observations I used four pupils from one class and observed them completing their coursework over three lessons in the summer of 2006. With roughly half as many pupils taking modular as applied science in the 2005-6 academic year, there were fewer classes from which to collect observational data, which is displayed on table 6.2.

Table 6.2 Results of learning approaches 2005/6

	Subject			
	Applied science		Modular science	
Learning area	Coursework	Classwork	Coursework	Classwork
Expressive				
Confidence	4	3	3.7	3.2
Cursiosity	3.8	2.7	3	2.3
Open-mindedness	3.4	2.6	2.7	2.3
Responsiveness	3.6	2.2	2.7	2.5
Productive				
Exploratory	3.6	2.8	3	2.4
Planning	3.6	2.2	2.7	2.3
Applying	3.6	2.2	3.2	2.2
Monitoring	3.8	2.2	2.6	2.2
Innovitive				
Adventurous	3.4	2.3	2.6	2.3
Flexibility	3.4	2.5	2.6	2.3
Creativity	3.4	2	2.5	2.2
Evaluating	2.7	2.3	2.5	2
Constructive				
Interest	3.5	3	3.5	3.2
Eliciting ideas	3	2.7	3.3	2.7
Restructuring	2.7	2.2	2.7	2.2
Application	2.7	1.3	2.5	2

1=least application, 5=most application

6.3 Analysis of learning approaches 2005-6

The most striking and immediate finding is that in both forms of science pupils were more innovative, expressive and collaborative when doing coursework than when doing exam based work. For example, on a scale of one to five, where five represents the most expressive or collaborative, and one the least, applied science students scored an average of 3.25 for innovativeness in coursework, and 2.3 for classwork.

The results could point to the need for team work, including helping and relying on others and coaching each other to get parts of the coursework done. More exam learning would seem to be completed individually. Coursework also allows for more innovation and independent learning, in pupils getting experiments to work, discovering problems and evaluating them. The learning is done by the pupils, not for them (Black and Harrison 2004). This is more of a constructivist way of learning with pupils working together to develop the constructs required by the coursework with the teacher helping to facilitate the change, as pointed out by Driver, Asoko, Leach, Mortimer and Scott (1994). This was borne out by the greater degree of constructive learning shown. However, pupils seemed to show more interest in listening to new constructs (3.5 for applied science and modular students in coursework), than they did in applying them (2.7 for applied, 2.5 for modular students at coursework). This is slightly more pronounced in applied science, particularly in the application of new scientific constructs where pupils have really struggled in exam lessons. Many pupils were interested in giving their ideas and having teachers listen to them, and field notes back this up:

'Teachers definitely take my [scientific] ideas seriously' (S1C12P17 26/09/2007)

It would seem from the results that pupils in this study seemed to lose the impetus they gained in having their ideas shared and discussed in lessons and did not, or could not restructure and apply new scientific ideas.

There is a clear product to coursework: the finished work, which makes the productive skills more apparent in coursework and gives more space for pupils to express their individuality. Investigations were defined as where 'pupils have to make their own decisions either individually or in groups: they are given some autonomy in how the investigation is carried out' and 'an investigation must involve pupils in using investigative processes such as planning, measuring, observing, analysing data and evaluating procedures' (Watson, Goldsworthy and Wood-Robinson 1999 p.102). Looking at the data, it would seem that to a large extent these aims were being met, even in the modular science investigations. The clear product of a piece of coursework does have to meet certain standards set by the exam boards. This is where coursework takes on more of a positivist approach; certain ideas of completing the work, of what coursework must contain must be met by pupils for them to achieve a grade. Within this framework, pupils can work together and innovate as to how they show what they have achieved.

There were more pronounced differences, particularly in the average expressive (3.0 for coursework, 2.6 for exam) and productive spheres (2.9 for coursework, 2.3 for exam), for modular science pupils. This could imply more scope for these skills in modular coursework and it could be linked to the reduced amount of coursework required by the modular scheme. Therefore, pupils could put a lot of effort into the coursework they had, rather than that work being routine as in applied science.

These results form only a guide to learning approaches in science and the particular pieces of work could have skewed the results, for example, if pupils were doing a topic they found particularly interesting or difficult that could affect the extent to which they were motivated to learn. However, the results point to learning approaches showing a greater emphasis on group-work, independent thinking, innovation and constructivism as hallmarks of good science in coursework based lessons. In the following academic years I collected a range of observations over a series of lessons to add to these results.

6.4 Pupils completing science coursework and exam work 2006-7

For this academic year I observed eight pupils completing classwork and coursework in each of the three science specifications. These are detailed in table 6.3.

Table 6.3 2006-7 Observations

Subject	Total number of pupils
Applied science	8
Science 2006	8
Separate science	8
Total	24

The applied science students were in year ten, and were completing coursework for their unit 1 portfolio and exam work for their exam in January 2008. The science 2006 pupils were in year ten and completing exam work for their summer 2007 modular exams, and coursework for a class based ISA in the weeks after the examination. The modular pupils in year 11 were completing their coursework and exam work for submission in the summer of 2007. The observations took place over three lessons for coursework and three for exam work, and the results were averaged to give an overall idea of learning approaches across the subjects. The results of the observations are detailed in table 6.4.

Table 6.4 Results of learning approaches 2006/7

Learning area	Applied science Coursework	Applied science Classwork	Science 2006 Coursework	Science 2006 Classwork	Separate science Coursework	Separate science Classwork
Expressive						
Confidence	3	4	3.2	2.7	3	3.2
Cursiosity	2.7	3.2	3.3	1.7	3.2	3.7
Open-mindedness	4	4	3.3	2	3	2.7
Responsiveness	2.5	1.5	3.3	2.5	3.2	2.7
Productive						
Exploratory	2.6	2.3	3.3	2.2	3.2	2.7
Planning	2.7	2	3.3	2	3.5	2.7
Applying	2.7	1.7	3.3	2.3	3	2.7
Monitoring	3	1.2	3.3	2.3	3.5	2.7
Innovitive						
Adventurous	2.7	3	3.2	2.4	3.2	2.7
Flexibility	3	2.7	3.2	2.2	3.5	2.7
Creativity	2.7	1.7	3.2	2	3.2	2.7
Evaluating	2.6	1.2	3	2.2	2.5	2.5
Constructive						
Interest	2.5	1.6	2.7	1.7	2.5	2.7
Eliciting ideas	2.6	1	3	2.2	3	3
Restructuring	2.3	1	2.7	2	3	2.7
Application	2.3	2	2.2	1.7	2.7	2.3

1=least application, 5=most application

6.5 Analysis of learning approaches 2006-7

The results displayed in table 6.4 show a similar pattern to the previous academic year with the pupils under observation showing a greater degree of learning through coursework. However, there are some discrepancies. In both the separate and the applied sciences pupils showed a greater degree of confidence (4 for applied classwork, 3 for coursework, 3.2 for separate classwork, 3 for coursework) and curiosity (3.2 for applied classwork, 2.7 for coursework, 3.7 for separate science classwork, 3.2 for coursework) when dealing with classwork. Perhaps the volume of applied coursework led to a lowering of interest for some, and the more academic outlook of the separate sciences led to many pupils putting more effort and having more confidence in this part of the course. This was not reflected in science 2006 students. Applied students proved more adventurous (3 for classwork 2.7 for coursework) with separate science students also adventurous (3.2) and more productive with classwork than with coursework (3 for classwork, 2.7 for coursework) perhaps with similar reasons than those mentioned above.

It was only the science 2006 students who showed greater levels of interest at coursework (2.7) than at classwork (1.7). According to Capel, Leask and Turner (1995) tasks that interest pupils and have relevance to them can promote active learning. This newer specification designed to elicit interest in science amongst students seems to have had more effect in the intensive coursework lessons than in exam based study, at this juncture.

Observational analysis of applied science students shows more constructivist learning in coursework lessons than in class work, with students taking responsibility for their learning and working purposefully, which Driver and Bell (1986) listed as being a part of constructivist science teaching. This could be connected to a perceived greater degree of importance placed on their coursework and a need to put their scientific understanding into it. The lesser role of the exam in their assessment could be why pupils felt less willing to take on board and use new scientific ideas. The difference was far less marked in separate and science 2006 students than in applied, which had particularly low levels of eliciting and restructuring ideas (stages two and three of Reiss's (1993) process of constructivism) in their exam lessons (1 for eliciting and restructuring) although they were more adept at applying what new ideas they had (2). Science 2006 and separate science learners had similar levels of interest (2.7 science 2006, 2.5 separate) eliciting ideas (3 science 2006, 3 separate), restructuring (2.7 applied, 3 separate) and application (2.2 science 2006, 2.7 separate) in coursework, which was consistent with the results from applied science, although they both had higher levels in exam lessons than applied.

In general separate and science 2006 students showed a slightly higher degree of productiveness in coursework lessons (3, 3.5) than their applied colleagues (2.7). Perhaps this led to a less intense effort placed on each piece of coursework in applied science, than in the other specifications, where one or two pieces count for the entire coursework component.

6.6 Pupils completing science coursework and exam work 2007-8

As with the previous year, I observed eight GCSE pupils completing classwork for examinations, and coursework in the three science specifications. The observations took place over three coursework and three classwork lessons in the 2007/8 academic year and the results were averaged to give an overall idea of learning approaches across the subjects. The cohort that I observed is detailed on table 6.5.

Table 6.5 2007-8 Observations

Subject	Total number of pupils
Applied science	8
Science 2006	8
Separate science	8
Total	24

As with the previous year, the applied science students were in year ten, and were completing coursework for their unit 1 portfolio and exam work for their exam in January 2009. The science 2006 pupils were in year ten and completing exam work for their summer 2008 exams, and coursework for a class based ISA in the weeks after the examination. The modular pupils in year 11 were completing their coursework and exam work for submission in the summer of 2008. The results are shown in table 6.6.

Table 6.6 Results of learning approaches 2007/8

	Subject					
	Applied science		Science 2006		Separate science	
Learning area	Coursework	Classwork	Coursework	Classwork	Coursework	Classwork
Expressive						
Confidence	3.2	3	3.3	3.3	2.5	2.2
Cursiosity	3.2	2.7	3.6	3.3	2.2	1.7
Open-mindedness	3.3	2.7	3.6	3.3	2.6	2.2
Responsiveness	3.2	2.7	3.3	3.3	2	1.7
Productive						
Exploratory	3.3	2.7	3.3	3	2.3	2
Planning	3.5	2.7	3.6	3	2.3	1.7
Applying	3	2.7	3.6	2.7	2.3	1.7
Monitoring	3.5	2.7	3.6	3	3.1	3.1
Innovitive						
Adventurous	3.2	2.7	3.2	2.7	2.6	2.3
Flexibility	3.3	2.7	3.3	3	3	3
Creativity	3.2	2.7	3.3	2.7	3.2	1.7
Evaluating	2.5	2.7	2.6	2.6	1.7	3.2
Constructive						
Interest	3.2	2.7	3.2	3.5	1.6	1.3
Eliciting ideas	3.2	3	3	3.3	2.3	1.6
Restructuring	3.2	2.7	3	3	2.3	1.6
Application	2.7	2.5	2.7	3	2.6	2.6

1=least application, 5=most application

6.7 Analysis of learning approaches 2007-8

Science 2006 students tended to be more productive and innovative in their coursework lessons but they proved to be as expressive, confident and skilful at evaluating in classwork lessons. In constructivism, they tended to show more interest in, and were better at eliciting their ideas and restructuring them with teacher help in theory lessons, which was the reverse of the previous year. On a scale of one to five, where five equals the most application, in 2006/7, science 2006 pupils were observed restructuring and applying new ideas at 2.7 and 2.2 respectively in coursework, and 2 and 1.7 in examination study. They were observed at level 3 and 2.7 for restructuring and applying coursework in 2007/8, but at 3 and 3 for examination work. At the same time, many science 2006 pupils were indicating that they were less enthusiastic about coursework in the questionnaires than those studying other specifications (in 2007/8, 51% of science 2006 students preferred coursework to examinations, separate science students were 61% in favour and 78% of applied science students were in favour of coursework) (section 4.6) Perhaps the importance of examinations and increased teacher skill and confidence in teaching the theory for the new specification, but not the coursework caused this. In the 2007/8 interviews (chapter 7.9) no teacher spoke of having increased skill and confidence in teaching science 2006. Field note evidence though does point to this:

> Once you've taught it for a year or so it becomes easier, you know what the specification is looking for (S1T402/07/2008)

The conceptions that teachers bring to their lessons can shape the constructivist nature of them (Driver and Bell 1986). A positive concept of science 2006 could influence the degree to which constructivist learning takes place.

In comparison, separate science learners in this study were equally more expressive and innovative when completing coursework, (scoring 2.3 for coursework expressiveness and 1.9 for classwork alongside 2.6 for coursework innovation and 2.5 for classwork innovation). They seemed to be similarly adept at monitoring (3.1) and showing flexibility (3.1) in both forms of work. They were generally more innovative and constructive (2.2 coursework, 1.7 classwork), when learning coursework. Eliciting and restructuring new scientific ideas proved to be more successful than gaining interest and applying new skills, as was the case with many of the initial analyses in 2005/6.

Applied students again followed the trend of higher levels of expressiveness (3.2 coursework, 2.7 classwork), productivity (3.3 coursework, 2.7 classwork), and innovation (3.1 coursework, 2.7 classwork), through their coursework. As with separate science learners, they tended to be better when having scientific ideas elicited than in applying their skills. It is the application of new ideas in their coursework that gives them their grades. When pupils have the opportunity to write scientific thoughts in their own words, it is beneficial to their learning, and enjoyable to them (Woolnough, McLaughlin and Jackson 1989). It would seem by looking at results data (chapter eight) that some of them were eventually able to apply new scientific ideas and achieve good grades.

Applied science students tended to be more productive, innovative and constructive in 2007/08 than in 2006/07. This may be due to increased teacher confidence and experience in teaching and delivering the applied coursework and classwork, having taught the course for three years by 2007/8. The changed specification of additional applied science in 2007/8 (section 2.2.5) with less coursework tasks to work on could have allowed pupils to put more innovation and production into completing those tasks. In terms of expressiveness, applied coursework learners were more expressive in 2007/8 than in 2006/7 but the reverse was true for classwork. Pupils may have been less expressive in examination lessons due to the 'facts' they needed to learn for their examinations.

6.8 Overall conclusions

Learning observation analysis has highlighted the role of constructivism in coursework and classwork, by showing the extent to which pupils showed interest in their work, offered ideas, and with teacher help restructured and applied them. In particular there were more pupils making meaningful constructs through coursework. This was highlighted in the 2005/6, 2006/7 and 2007/8 analyses. The results consistently showed that pupils in this study showed interest, offered scientific ideas, restructured new ideas and applied them to a greater degree in coursework lessons than in exam learning lessons. This could have been due to the need for coursework to be completed to the highest standard within a small time framework in order to gain good marks. Driver and Bell (1986) inferred that learners are purposeful and responsible for their own learning. Where the learning is done by the pupils, not for them (Black and Harrison 2004), pupils tended to work more innovatively and independently. Coursework gives more opportunity for pupils who want that responsibility to build, and reconstruct scientific ideas and this was reflected in the results. An exception was science 2006 in 2007/8 where pupils learned more constructively through classwork, which could have been due to the importance of examinations and increased teacher skill and confidence in teaching the theory for the new specification.

Additional evidence of constructive learning, and the role of teachers, comes from field notes. When asked 'How are your scientific ideas treated by teachers' in order to investigate how pupil views are used and changed by teachers, in a constructivist way (section 2.4.2), in order to respond to research question three, a mixed ability year 11 applied science class engaged in a coursework activity came out with the following answers:

> 'Teachers listen to my ideas, sometimes they do laugh but they do listen' (S1C12P1 26/09/2007)

> 'My scientific ideas are taken seriously' (S1C12P13 26/09/2007)

Below are some responses to the question 'Are your views changed by science?'

> 'Yes indeed, I know all about things like global warming now and I agree with it' (S1C12P6 26/09/2007)

> 'Yes they are, I know now that carbon dioxide can be bad' (S1C12P4 26/09/2007)

Below are some responses to 'Can you relate science to everyday life'

> 'You could – It's what you learn. I know now how to read food labels and check the fat' (S1C12P12 26/09/2007)

> 'Dunno but you can, like global warming – I know how my everyday life can change the weather' (S1C12P9 26/09/2007)

The questions were based on Reiss's (1993) table outlining the elicitation, restructuring and application of science through constructivism (Table 2.3) The results demonstrate that the students who were asked felt that teachers listened to their ideas, that their ideas could be changed by science, and they felt able to apply their ideas outside of the lab. 'The role of the teacher is to help pupils to make sense of how knowledge can be generated and validated' according to Driver, Asoko, Leach, Mortimer and Scott (1994 p.5). This is evidence that in the case study school, some students were being taught, and were learning constructively through science.

I questioned teachers as to their use of pupil misconceptions to ascertain how they were built on or changed, as a part of constructivism, within my response to research question three. The evidence indicated that some teachers used a constructivist approach in the classroom, particularly in coursework lessons planned over a long period of time, where pupil ideas and misconceptions helped to mould individual lessons, and longer term planning:

> 'You have a long term plan, and over the space of one lesson you don't get far because so many students have misconceptions and you spend all of the lesson working with them to modify them, or you find that they know the stuff so well you end up extending them and pushing them' (T1S2 24/06/2008)

However, a number of teachers spoke of teaching in a more positivist way, the 'facts' required to pass GCSE examinations:

> 'You always teach to the exam at GCSE level, there isn't time for discussions or eliciting ideas' (T4S1 12/05/2008)

Pupils were generally more creative when completing coursework. However, field note evidence revealed mixed feelings about pupils when questioned about choosing their own ideas for coursework:

> 'It would be better as it would be less 'robot' kind of work' (S1C8P18 19/06/2007)

The term robot may have referred to pupils completing very similar pieces of work. This pupil was possibly concerned about not having originality in their work. Alongside this, a respondent in the 2007/8 questionnaire wrote that they wished their coursework could be more creative. However other pupils had very different opinions:

> 'I'd rather have a design to work from' (S1C14P9 16/10/2007)

> 'I wouldn't know what to do if I had to do it myself' (S1C14P3 16/10/2007)

> 'I wouldn't like to choose what to do, it is easier and better if the teacher does it for me' (S1C8P1 19/06/2007)

This exchange demonstrated the individual ideas pupils bring to learning science. While some like to innovate and maintain originality, others are less concerned with such issues and are more interested in completing their work with the least problems.
Teachers, when asked about assessment for learning in the classroom (e.g. pupil and peer assessment, teacher written and verbal feedback), which has much in common with constructivism, had mixed feelings (chapter seven). Some spoke of a lack of AfL opportunities in science 2006. Other teachers thought applied science gave AfL opportunities but not Science 2006, whilst others opined that they gave AfL feedback comments, but pupils would not apply them. Despite observational analysis that pupils were able to restructure their knowledge and take responsibility for their learning, some teachers did not feel that this was happening.

In some observations, including applied science and separate science in 2007/8, pupils were better at having new ideas elicited than they were at applying them. However by the time they had finished their coursework many had applied enough new scientific information to achieve, for them, excellent grades. It would seem that applying new ideas takes place over a longer time frame than a few lessons.

The results initially pointed to a greater degree of interest and ideas amongst learners and less ability to restructure and apply new ideas. This inferred that pupils may tend to lose the impetus that they built up early in lessons. However, in some cases in the latter years restructuring and application in all subjects was at a similar level to interest and ideas. This implied that many pupils and teachers in this study had become more adept at using and applying scientific ideas, particularly in the newer specifications. When pupils have the opportunity to write scientific thoughts in their own words, it is beneficial to their learning, and enjoyable for them (Woolnough, McLaughlin and Jackson 1989).This was not the case, however with the separate sciences in 2007/8 where many pupils used to the older modular coursework were faced with learning the new science 2006 form of coursework which themselves and teachers may have been less adept at teaching and completing.

In terms of active learning, in which work has individual importance to each pupil (Black and Harrison 2004), the same is true. Pupils tended to be confident creative, adventurous and responsive in their work although there were some discrepancies between the specifications. In both the separate and the applied sciences pupils showed a greater degree of confidence and curiosity when dealing with exam study in 2006/7. This is a possible reaction to the sheer volume of coursework in applied science, and the need to learn for examinations, which constitute a far greater percentage of overall separate science grades.

Overall, these results outline that the students I have observed have been expressive, productive and innovative in their science learning, and they learn their science through constructivist methods. There is a greater degree of learning in coursework than in exam lessons. Exam study did not give the scope for teamwork, innovation, flexibility and constructive learning that coursework allows. Instead there is an emphasis on learning for one's self rather than a need to share results and work together in groups to process conclusions. Although coursework must be written up individually, results can be shared.

The learning approaches sample size was small, with 12, 18, and 18 students observed over the three years of the investigation. A smaller sample size allows for more detailed analysis (Cohen, Manion and Morrison 2000) and the method of sampling can also have an influence on sample size (Powell 1979). In undertaking a detailed analysis of a small number of pupils, rich and detailed data has been obtained. There is, however, a risk that variation inherent in the behaviour of some if the individuals observed may have more of a bearing on the overall results than they would if the sample size was larger (Cohen, Manion and Morrison 2000).

Having undertaken a series of studies concerning to what extent pupils learn in science, how they learn in science and what they think science coursework and examinations, the next chapter asks for the opinions of teachers, concerning the same topics, in order to further develop my response to research questions one to four.

Chapter 7

Teacher interviews

7.1 Introduction

This chapter aims to ascertain the views of teachers, which can then be related to their role in the teaching of science, in order to respond to research questions one to four. Teachers from three schools, all teaching applied science, modular science and science 2006 using the AQA specification were interviewed. They were informed of the purpose of my research, under the principle of informed consent (David, Edwards and Alldred 2001, University of Gloucestershire 2009a). Their comments were treated confidentially and names were not mentioned.

My views and the impact of change on my teaching as opposed to that of colleagues is outlined in section 9.5 entitled Reflexivity in the research process. A sample of three completed interview sheets can be found in Appendix 11.

7.2 Teacher interviews 2005-6

Following the coursework completion deadlines in 2005-6, I asked a number of questions to various colleagues involved in the collection, marking and moderation of GCSE coursework. Table 7.1shows the number of respondents and schools involved.

Table 7.1 2005-6 Interview respondents

School	Number of interviewees
1	6
2	1
3	0
Total	7

I interviewed seven science teachers, six from the main school of this study. They were all classroom teachers, none with management roles. I wanted to do this whilst coursework was at the forefront of colleagues' thoughts following a 'hotspot' in the month of May during which time GCSE, entry level, Applied GCSE, AS level and A level coursework was to be moderated and sent to the exam boards. The interviews were conducted during June 2006. A copy of the question paper can be found in Appendix 8.

7.3 Responses to the 2005-6 teacher interviews

Question 1 **'how have you found the coursework experience this year in comparison with teaching for exams?'** brought out a range of responses. One described the whole thing as 'bullshit'. No other explanation as to why was offered. Another recounted a past story of having sent coursework consisting of a number of pages to a moderator with each corner stapled:

> 'The work apparently came back as having been checked yet the staples were untouched, meaning that apart from the first page, none of the work had been checked'

Others worried that pupils needed too much help:

> 'I had to intervene lots for them' otherwise they would not get the work finished or improved at all'

Question 2 **'do you think it builds pupil ability?'** encouraged some respondents to agree that coursework does not build pupil ability, apart from the ability to write coursework. One interviewee complained that:

> 'It's not extrapolated across anything - they don't learn from it just how to do it...they just have to do it to pass their science and that is that'

Another teacher echoed similar sentiments:

> 'No, it does not end up teaching them owt, just how to write up their coursework to hopefully get a pass'

These respondents echoed the general feeling of a lack of belief that coursework builds pupil ability.

For question 3 **'how much help did you end up giving them?'** the replies were varied, but a theme emerged of teachers having to give a lot of help. One person admitted:

> 'I have helped my students with 60 pieces of coursework, I have three classes and all of them need lots of assistance'

Another said they had helped individual pupils to prepare alternative coursework conclusions so that their work would not appear the same to exam board moderators. Another complained of being 'tired from helping them all do it' [the coursework].

Question 4 **'do you think the coursework deadlines for different subjects should be more spread out?'** was answered by most respondents who were in agreement with a more spread out set of deadlines, with answers such as 'definitely' and 'I think so' although none went on to speculate as to which subjects should be assessed earlier or later.

The last question **'How did you find marking and moderating it?'** allowed for some varied responses. One answer was 'it knackered me out'. There were complaints about having to re-mark work left by staff who had failed to mark it or to apply the mark scheme correctly:

> 'It is difficult to apply such a wide [applied science] mark scheme. There are so many different marks for different topics and we have to get them right'

7.4 Analysis of teacher interviews 2005-6

Some teachers at the start of this research were rather negative with many respondents describing how they had to help pupils too much. This is similar to Jones Gott and Jarman's (2000) finding that teachers thought their pupils needed too much help to complete their coursework. It could be described as an example of a one way dialogue from the teacher to the student, about how to improve their work (Carnell, in Askew 2000). No teachers referred to coursework illustrating concepts and developing skills and processes as Gott and Duggan (1995) found when questioning teacher views of pre applied science coursework.

A number of interviewees also considered that the coursework did not build ability. This was evidence that coursework, in its pre science 2006 guise, to the teachers of this study, may have been unsatisfactory in terms of building pupil ability. However, the National

Endowment for Science, Technology and the Arts (2006) found that 87% of the teachers they questioned considered that scientific enquiry was important for learning.

Many teachers mentioned being tired from marking or re-marking the coursework. This could be connected to issues of staff training in marking and moderating different coursework components as they are introduced. The year of these questionnaires was one of applied science coursework being submitted for the first time.

7.5 Teacher interviews 2006-7

This academic year represents the introduction of science 2006 to year ten pupils. Teaching this alongside applied science and modular science has given me a unique opportunity to ascertain the views of colleagues bridging the gap between schemes.

Following the coursework completion deadlines in the 2006-7 academic year, I used the same interview questions as for the 2005-6 academic year, but with two additional questions to reflect the introduction of how science works and the use of assessment for learning techniques (including peer and self assessment by students, and using verbal and written teacher feedback to improve work) in science (Appendix 9). I felt these questions to have been successful previously in answering my research questions whilst being sufficiently open ended to allow for other meaningful insights.

I interviewed a total of eight science teachers at three schools in June, during the summer of 2007. All were teaching the AQA specification. Table 7.2 displays the number of respondents and schools involved in the interviews.

Table 7.2 2006-7 Interview respondents

School	Number of interviewees
1	6
2	1
3	1
Total	8

Interviewing teachers from other schools gave breadth to the data, by providing a range of experiences and views. Their roles included an advanced skills teacher (a teacher on a higher pay-scale based on their teaching ability) a second in department and a number of classroom teachers. By interviewing in the summer not only was I using teacher time when teaching timetables are at their lightest, but I was also getting the benefit of an academic year of experience with science 2006.

7.6 Responses to the 2006-7 teacher interviews

One particular response to question one, **'how have you found the coursework experience this year in comparison with teaching for exams?'** pointed out that:

> 'Science 2006 seems exactly the same as modular pre 2006 science. The only things that changed are the textbooks and the specifications, allowing book publishing companies and exam boards to make an extra bit of profit'

Others took a more positive view. One noted how:

> 'Coursework is now easy to set and incorporate into schemes of work. It doesn't take up the same amount of time that it used to'

One teacher noted that it was a constant pressure and another described it as a lot of effort to mark. Two respondents mentioned that there was much coursework and one stated that 'we have to give a lot of help' as did respondents in 2005-6. One said they were worried that the new coursework in science 2006 would lead to lower results, as there is less scope for pupils to improve their work.

For question two, **'do you think it builds pupil ability?'** one respondent the skills that pupils gained from coursework:

> 'Through coursework, good practical skills are now developed through the experiments they have to do, but not much knowledge skills are gained'

Others considered that only certain pupils made improvements. One respondent thought that 50% of learners would make progress, another thought that 'select pupils' would benefit:

Another respondent enthused as to how:

> 'Pupils can see their progression through [applied science] coursework'

Further respondents thought coursework did not build ability, including the following:

> 'I do not believe pupil ability has changed whatsoever from the coursework experience this year'

In terms of question three, **'how much help did you end up giving them?'** the consensus was more than should have been given, as in 2005-6. Answers ranged from 'they need clear instructions', to 'I'm constantly marking and remarking work', that Popperian idea of improvement through criticism of the flaws in a piece of work. One person was keen to point out that:

> 'It varies; some [students] would work by themselves as independent learners with maturity. They do improve each lesson'

Whilst another opined that:

> 'Some students are able to see their progression and don't need much help. They can work independently mostly'

For question four, **'do you think the coursework deadlines for different subjects should be more spread out?'** a variety of answers were given. One stated that their schools had 'targets for different subjects organized throughout the academic year'. The consensus though, was for 'yes' as in 2005-6. Other comments included that' it is de-motivating having all coursework deadlines at the same time' and that 'all students and staff should work to one predetermined deadline'.

For number five: **'How did you find marking and moderating it?'** some positive responses were elicited unlike in the previous year. One respondent claimed:

> 'Students find it more straightforward to complete the science 2006 coursework. The marking is more straightforward with crucially students having a greater understanding of what they are being assessed for'

Others complained that marking was hard work and one person expressed concern that 'not knowing the grade boundaries make things [moderating and marking] difficult'. Another stated that assessing whether a piece of work was grade C or D boundaries was difficult.

For number six: **'How have you found teaching how science works?'** there was some negativity in responses. One respondent found it difficult to link the coursework to theory, finding it 'difficult to ensure relevance'. 'Not good' was another succinct answer to this question.

Another questioned how:

> 'Teaching how science works is poor, students don't want to use their minds to organise or analyze results'

One positive respondent stated that science 2006 coursework is better overall: 'it is done in time with no cheating'.

The final question **'Do pupils have much opportunity to use AfL in their coursework?'** uncovered variation between the specifications. One interviewee considered applied science to give AfL opportunities but not Science 2006:

> 'Applied science definitely allows for individual feedback but not the new science'

Another thought that they tried to give written feedback comments but pupils did not respond to them:

> 'Do they use my comments? I still end up telling them what to do!'

Thus for this individual, written feedback was more effective. Another thought pupils unable to apply AfL in terms of self and peer assessment and teacher feedback to their work.

7.7 Analysis of teacher interviews 2006-7

Teachers in 2006-7 gave a range of responses, with slightly more optimism overall than in the previous year. Some were welcoming of the science 2006 approach: 'it is easy to set and incorporate in to a scheme'.

Some pupils, it was thought, benefited from coursework, a change from the previous year. Again, a number of teachers thought that pupils did not work independently enough and that coursework deadlines should be spread out although some had other ideas such as giving everyone the deadlines at the start of the year. Some teachers thought that they had to give a lot of help to pupils although one pointed out that 'some [students] would work by themselves as independent learners'. Help and advice from teachers was poorly defined and open to interpretation, according to the QCA coursework report (2006g). Thus overt help could be defined as telling pupils the answers or telling them what to write.

Marking and moderating was generally considered straightforward for science 2006; 'it's easy now, the tasks are more straightforward', but assessing if work is C or D was difficult. This is an area scrutinized by moderators. How science works was seen by one interviewee as 'difficult to link to scientific theory and difficult for pupils to analyze' although another noted how 'it is important and interests pupils'. AfL in terms of using teacher, self and peer assessment to improve coursework, was useful in applied science, where pupils acted to improve their work, but not science 2006. Overall, teachers seem to have adjusted to applied science and were able to show how AfL is used in it: 'applied gives them the opportunity', but science 2006 and the how science works section were given a mixed greeting with some pleased about the way coursework was completed in one go but the aforementioned lack of AfL was mentioned.

7.8 Teacher interviews 2007-8

As with the previous years I interviewed teaching colleagues after the coursework deadlines, in June 2008. Respondents to the interviews are detailed on table 7.3.

Table 7.3 2007-8 Interview respondents

School	Number of interviewees
1	6
2	1
3	1
Total	8

I interviewed eight teachers from three different schools including a key stage three coordinator, a physics coordinator, a vocational science coordinator and four classroom teachers.

I added three questions for 2007/8 to ascertain teacher viewpoints about constructivism (Appendix 10), in order to respond to research question three, with particular reference to constructivism. This included their use of pupil ideas in lessons and whether pupils gain a meaningful understanding of science that they can use outside the lab, based on Reiss (1993). A discussion of these questions can be found in chapter 3.83. The rationale behind this was to obtain data relating to how constructivism, which has been described as an essential component of science education (Russell and Watt 1990, Capel, Leask and Turner 1995), and is embedded in the National Curriculum (Littledyke 1998), is understood and used by teachers in their teaching, and in the learning of pupils. This is important when researching how children learn when doing their science coursework examination work, and the data has been incorporated into the answers for research questions three and four.

7.9 Responses to the 2007-8 teacher interviews

For question one, **'how have you found the coursework experience this year in comparison with teaching for exams?'** a range of responses, as with previous years, was uncovered. One respondent described how:

> 'It is good, the results are visible for pupils, the pupils can actually see themselves improve'

This is an example of how improvements due to teacher feedback and self assessment can lead to improved grades. Others dismissed it as 'demanding' and or 'just hard work'. One went further, describing how:

> '[It is] difficult, when students are absent and miss practical sessions, they cannot just be given notes to revise. Impossible to split parts of coursework with other staff who share groups – exams are much easier'

In terms of question two **'do you think it builds pupil ability?'** there were mixed opinions. One interviewee considered both sides of the argument:

> 'Yes – coursework can teach practical skills...and no, because many teachers have to provide too much help and structure so that they can do it'

Another person offered a similar opinion about how coursework can build ability:

> 'They can learn practical techniques which are helpful in life and if they want to proceed with their science further...to A levels'

One interviewee disagreed noting that 'pupils have to jump through hoops'. Another considered that coursework built ability 'partly, but not as much as it should', without offering an answer as to why.

For number three, **'how much help did you end up giving them?'** some answers, as with previous years, pointed to a large amount.

One respondent spoke of pupils not working independently;

> 'Too much help...I have to suggest improvements and make sure they do them. Results would be poor otherwise'

Another talked of giving pupils chances to improve which is surely one of the benefits of coursework:

'I give them a lot of chances to improve and I suggest improvements which lots take on board and do'

For question four, **'do you think the coursework deadlines for different subjects should be more spread out?'** many teachers responded with 'yes' as in previous years. Only one respondent extrapolated their response, saying:

'Yes definitely, the pupils feel stretched and pulled between subjects, in that they have deadlines to meet and different teachers chasing them up at the same time'

For number five: **'How did you find marking and moderating it?'** one person described it as 'generally o.k.' Another mentioned how it was time consuming; 'it takes ages to apply the mark scheme' and there were two negative comments deriding it as 'boring' and 'tedious' respectively. The need to remark improved work was summed up as 'it is repetitive: mark – draft – remark'. There was no mention of the difference between marking science 2006 and the other specifications unlike the previous year.

For number six: **'How have you found teaching how science works?'** three interviewees did not offer an opinion, possibly as they had not considered that they taught this distinct from scientific theory.

One offered the following:

'Fine, I have had no problems with the science. It is hard to fit it in alongside the subject matter for the exams though'

However, an alternative view came from another teacher who thought the concept [of how science works] was 'difficult to understand'.

One thought it 'the same as the previous modular specification'. Another described how some 'snippets of real life' can relieve the boredom of the topic.

Question seven **'Do pupils have much opportunity to use AfL in their coursework?'** invited a comment about how some specifications lend themselves to AfL more than others:

'AfL is in applied science but not in science 2006. You used to be able to use it before science 2006 came along'

Another interviewee agreed, answering 'no, not any more with science 2006'. This is concurrent with answers from the previous year. Only one teacher thought that pupils could use assessment for learning, in terms of using teacher, self and peer assessment to improve work. Another was cautious; 'they [pupils] can work with checklists to improve their own work'. 'They do [have opportunities to apply AfL] but rarely use it' was another response.

Question eight **'What use do you make of children's concepts and ideas of science?'** gave one answer stating 'yes I use them lots, particularly to start lessons'.

Another used children's concepts thus:

> 'To identify misconceptions which can be corrected when I plan my lessons in the future'.

A third teacher used children's concepts 'to plan future teaching'. Some respondents were less positive, one stating that they did not use it 'as much as I intended'. Two people said they did not use children's concepts whilst two did not comment.

Question nine **'Do exams and or coursework give pupils a meaningful understanding of science?'** gave two 'no comment' answers. One respondent reasoned that 'it depends on the motivation of pupils'. One agreed, without extrapolating their reasons. One considered the positive effects of coursework on learning:

> 'Coursework helps them understand science more than reading up for an exam...they learn by doing it for themselves'.

However, another teacher had the opposite opinion:

> 'Exams do give more understanding of science than coursework, which confuses them with all the different mark schemes and things they've got to do'.

For the final question 'Do you think they use their science to understand the world outside the lab?' again two people declined to comment, possibly as they were unsure or had not thought about it before. Two opined that it depended on the intelligence of the pupils, one stating that 'more intelligent pupils use their science more', another reasoning that 'the ones who are better able to think outside the lab will'. The other answers were 'rarely', 'in some topics like the environment' and 'no'.

7.10 Analysis of teacher interviews 2007-8

Some teachers found delivering coursework a good experience for themselves and pupils: 'pupils can see themselves improve', while others derided it as boring and 'pupils have to jump through hoops'. Some were positive on coursework building pupil ability: 'I give them a lot of chances to improve and I suggest improvements which lots take on board and do', as Jones Gott and Jarman (2000) found in their study. Every interviewee thought that deadlines should be more spread out for different subjects. There were mixed opinions about marking coursework and teaching how science works, including some who gave no answer to the latter. Perhaps they did not consider it a distinct part of the science curriculum. The lack of AfL opportunities in science 2006 was mentioned by three teachers.

In terms of constructivism, only three people claimed to make use of children's ideas in their lessons including: 'yes I use them lots, particularly to start lessons'. Some teachers agreed that only the more able pupils could make use of science outside of the classroom or gain a meaningful understanding of the subject. Two declined to comment on any of the constructivism questions. Their responses may echo the findings of research conducted by Halai and McNicholl in 2000. They researched the attitudes of nine trainee teachers in the UK, and 22 science teachers in Pakistan, analysing the results of discussions into the nature of science. They found that many science teachers were not aware of what science is. Many teachers held views, such as that science is theory based and value free, and that the scientific method provides objective truth. The former view, they declared, is not compatible with a constructivist outlook on science education. Field note evidence from questioning teachers as to what constructivism, in order to respond to research question three, is revealed the following answers when the concept was discussed with four science teachers during a departmental meeting:

'I don't know, sorry' (S2T12 02/03/2009)

'I haven't heard of that. Is it to do with scaffolding ideas?' (S2T2 02/03/2009)

This shows that the five teachers I questioned admitted not knowing what constructivism is. Despite this, observational analysis (chapter six) revealed that many pupils were having their ideas elicited, and replaced by scientific constructs, which would indicate that they are being taught, and are learning, in a constructivist way, consummate with Reiss's (1993) table of the process of constructivist learning (table 2.4).

However, this is limited evidence from which to draw conclusions about teacher knowledge about constructivism. It is a topic which would require further, and more substantial, research.

7.11 Overall conclusions

Teachers over the years of this study have had mixed feelings about coursework. Some criticised the lack of assessment for learning inherent in science 2006: 'they were able to before science 2006' whilst others praised it, finding it easier to incorporate into schemes of work and giving pupils a more meaningful understanding of science.

In 2005/6 as the older coursework was phased out, many teachers did not think that coursework built pupil ability. In 2006/7 opinions were changing, with more teachers noting pupils developing practical skills and seeing progression in their work. In 2007/8 similar opinions were echoed although in both years some had negative thoughts. In the latter years, there were some similarities with answers from Gott and Duggan's (1995) study where teachers reasoned that investigative work developed skills and processes. A review by the QCA in 2006 (QCA 2006e) found a large number of teachers to be positive about coursework with many commenting on how it gives pupils independent working skills. Earlier research by the QCA (2006c) in 2003/4 found just over 50% of the 138 science teachers they questioned agreed that coursework is a valid means of assessment. 45% disagreed. This mirrors the pattern of teachers becoming more positive towards coursework towards the end of this study. Many pupils in this study, particularly those studying applied science, separate sciences and science 2006 thought that they learned more effectively through coursework.

Pupils reasoned that teachers were training them to do investigations to get the right results without giving them the correct understanding (Toplis and Cleaves 2006). Comments of this sort were given by teachers through the three years e.g. 'it makes them jump through hoops' in 2007/8. This shows a form of extrinsic learning where results are obtained to achieve certain marks rather than to reason why they were achieved (Harlen 2004). For example, the modular science coursework specification (AQA 2004b), required pupils to comment on the quality and validity of evidence, recognising anomalous results and considering improvements. By achieving anomalous results, pupils would be able to point them out and discuss improving their experiment, and achieve a high mark for doing so. Thus, anomalous results were encouraged. Pupils in Toplis's (2004) study commented on the need for inaccurate anomalous results in coursework investigations to get more marks.

A colleague, during a moderation meeting for year ten coursework, considered what pupils learn through coursework from a teacher's perspective, stating that:

> 'They don't extrapolate their [coursework] knowledge in any way, they don't learn from it, just how to do it' (T1S1 26/06/06)

The role of the teacher in coursework investigations is to apply skilful and appropriate questioning according to Gott and Duggan (1995). They continued by considering how child centred learning has led to a reduction in didactic teacher led work, suggesting that a teacher should interact in a flexible manner with pupils. The emphasis should be on individual needs of pupils and 'enabling' questions to encourage thinking and discussion. However, in 2005/6 a number of teachers teaching the old modular scheme complained of having to give a great deal of assistance to pupils when writing coursework. This could be described in terms of one way dialogues from the teacher to the student, about how to improve their work (Carnell, in Askew 2000). By 2007/8, with the advent of science 2006, many teachers were still saying they gave too much assistance. The QCA coursework report (2006g) declared that help and advice from teachers was poorly defined and open to interpretation. Where teachers have to give a large amount of assistance, pupils may not be assessing their own work and working out how to improve it.

In agreement were two pupils who indicated that coursework was easier to cheat in their 2005/6 interviews. Jennings (1992) noted that pupils can copy when they complete the same task (section 2.4.8). 2005/6 was the last year of modular coursework. In the following years of the questionnaire, no pupils mentioned cheating. Cheating has been linked to extrinsic goals, such as overall exam results by Anderman, Griesinge and Westfield (1998) who also found no gender link to cheating pupils.

A lack of assessment for learning opportunities, in terms of pupil, peer and teacher assessment and feedback in science 2006 was mentioned by some teachers. A number of teachers thought applied science gave AfL opportunities but not science 2006. Other teachers thought that they gave pupils AfL feedback comments, but pupils would not apply them. However, constructivism was used to an extent by teachers. Some were enthusiastic about their use of pupils' ideas, extrapolating on how they start lessons with them or how they use them to identify misconceptions or plan future lessons. Others opined that only the more able or motivated were able to use their science outside of the lab or establish meaningful scientific constructs through their learning. McNally (2000) reasoned that some pupils built up meaningful constructs outside of the lab, in areas that interested them, but did not use them in the classroom. There were contrasting opinions as to whether coursework or examinations gave pupils a more meaningful understanding of science: 'depends on the students...if they are motivated' (2007/8).

Teachers had mixed feelings about marking and moderating work. Some found it difficult, tedious or time consuming. Teachers indicated in a questionnaire by Jennings (2000) that they were unhappy with the marking and administration of coursework. Others in my questionnaires had no problem with it. There was a unanimous opinion that coursework deadlines should be more spread out as it pressures pupils and teachers; 'pupils feel stretched and pulled between subjects' as one colleague in the 2005/6 interviews stated. A particular pressure on teachers of coursework is the moderation process where samples of work are sent off to be remarked to make sure the marks fall within certain levels. If they do not, the entire sample from a school could be asked for and the entire cohort of pupils marked up or down.

The sample size has been consistent through the three years of this investigation with seven, teachers interviewed in 2005/6, eight in 2006/7 and eight in 2007/8. In undertaking interviews with a small number of teachers, rich and detailed data has been obtained. There is a risk that variation inherent in the responses of some if the individuals observed may have more of a bearing on the overall results than they would if the sample size was larger (Cohen, Manion and Morrison 2000). However the populations of science teachers are small and the sample size has allowed for rich and varied data to be collected.

Having investigated and concluded the views of teaching staff in order to add to my response to research questions one to four, the next chapter explores the results data for GCSE science in terms of coursework and examination results across the specifications. Statistical testing is employed and significant differences between various sets of results are explored, in order to provide answers to research question two.

Chapter 8

Quantitative analysis

8.1 Introduction

This chapter is based on the use of quantitative techniques to ascertain possible significant differences between the different GCSE science courses, so that I can declare, with a stated level of confidence where significant differences appear to apply. As with previous chapters the data and findings have been presented chronologically, followed by an overall conclusion at the end of this section. I have used the t-test and the Bonferroni correction, detailed in section 3.6, to analyse the data. These findings have been used to answer research question two 'what are the variations in attainment between GCSE science coursework and examination study?', and by intertwining them with the qualitative data, they have aided in answering research question four, and justifying the overall conclusions.

The data is derived from GCSE results for the science specifications detailed in the study, at the main school of the study. All data has been treated confidentially, with names removed.

8.2.1 Coursework and examination attainment 2005-6

This was the first year in which applied science pupils completed their GCSE. Other pupils undertook the modular science examination and submitted modular coursework. Table 8.1 details the subjects and number of students whose results were analysed.

Table 8.1 2005-6 Analysis cohort

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	29	50	79
Modular science foundation	18	7	25
Modular science higher	12	10	22
Total	59	67	126

Table 8.1 highlights applied science as the most popular course in 2005/6, with a group of learners also completing the modular foundation and higher specifications. Table 8.2 shows the results of the t-test analysis, which showed only one significant result; between modular higher coursework and examination grades.

Table 8.2 T-test results for coursework and examination attainment 2005-6

Test	df	N	Sd	Result
Applied coursework and exam grades	156	158	17.89	0.32
Modular foundation coursework and exam grades	48	50	14.91	0.052
Modular higher coursework and exam grades	42	44	10.26	5.13***

*<p.05, **<p.01, ***<p.001 (using Bonferroni correction)

T-test analysis revealed a significant difference at the 0.001 level for the test between modular science higher coursework and exam scores, indicating a one in 1000 chance that the result may be due to chance. This showed that coursework marks were significantly higher, for higher modular science, than for examination.

8.2.2 Analysis of the 2005-6 data

In modular science, coursework could be marked and improved, allowing pupils to build on their marks and assess how they could achieve better marks. Where this is done by, rather than for pupils, they are learning actively through science (Black and Harrison 2004). It is also of note that it was the more able science learners who may have been able to significantly improve their coursework more than those studying applied or modular foundation.

8.3 Male and female coursework and examination attainment 2005-6

This section of the research aims to support and enrich the questionnaire data I assembled about boys and girls views of coursework and examinations in chapter four by uncovering any significant differences in the results data between the sexes. The results of the analysis are detailed on table 8.3.

Table 8.3 T-test results for male and female coursework and examination attainment 2005-6

Test	df	N	Sd	Result
Applied science male/female coursework	77	79	22.44	0.27
Applied science male/female exam	77	79	11.86	0.28
Applied male coursework/exam	56	58	18.08	0.20
Applied female coursework/exam	98	100	17.87	0.42
Modular science foundation male/female coursework	23	25	18.91	0.06
Modular science foundation male/female exam	23	25	9.16	0.05
Modular science foundation male coursework/exam	34	36	16.90	0.16
Modular science foundation female coursework/exam	12	14	5.65	0.02
Modular science higher male/female coursework	20	22	4.20	0.20
Modular science higher male/female exam	20	22	6.26	0.38
Modular science higher male coursework/exam	22	24	9.34	0.00024
Modular science higher female coursework/exam	18	20	11.51	1.26

*<p.05, **<p.01, ***<p.001 (using Bonferroni correction)

All of the results of the t-test analysis in table 8.3 were well below the critical levels, indicating no significant differences.

8.3.1 Analysis of results data

Possible male and female variations were not borne out by t-test analysis. Boys and girls coursework and exam grade comparison values for applied and modular science were all well below the critical value, indicating no significant differences between them. This is different to the findings of Elwood (1999) who found that in modular science, girls achieved significantly higher coursework scores than boys, at the 0.05 level. There was one result which was close to the critical level; modular science higher girls' coursework and exam grades. Although there was no significant difference between them, girls' coursework grades were higher than those for examinations.In 2005/6, in the main school of this study, I can conclude that there were no significant differences between boys and girls coursework and exam scores in the applied and modular specifications.

8.4 Coursework and examination attainment 2005-6 2006-7

In this academic year the final cohort of pupils took modular science examinations whilst the majority completed the applied science course. This is shown on table 8.4.

Table 8.4 2006-7 Analysis cohort

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	44	42	86
Modular science foundation	21	17	38
Modular science higher	5	5	10
Total	70	64	134

The results of the analysis are detailed on table 8.5 which highlights the significant differences between coursework and examination scores in the higher and foundation tiers of the modular science specification.

Table 8.5 T-test results for coursework and examination attainment 2006-7

Test	df	N	Sd	Result
Applied coursework and exam grades	170	172	12.25	0.001
Modular foundation coursework and exam grades	74	76	14.09	3.08**
Modular higher coursework and exam grades	18	20	11.37	5.13***

*<p.05, **<p.01, ***<p.001 (using Bonferroni correction)

The 2006-7 data shows a difference between coursework and examination scores across both modular subjects. Coursework scores were better, as was the case with modular higher in 2005-6.

T test analysis revealed a significant difference between modular foundation exam and coursework scores at the 0.01 level, and a significant difference for modular higher at the 0.001 level. This was not mirrored in applied science. In this academic year, statistical testing indicated that significantly higher scores existed for modular, but not applied coursework.

8.4.1 Analysis of the 2006-7 data

To sum up the 2006-7 data, for the main school of this study, modular higher science students continued to have significantly higher coursework scores than those achieved in examinations Modular foundation students also had significantly better coursework scores, but not as significant as those studying the higher tier. This was not repeated in applied science. This could be because specifications containing a lower percentage of coursework, allow pupils more time to complete, and improve on, that coursework. More able or more motivated students, studying the higher level modular science, may have been more adept at applying assessment for learning techniques to improve their grades. The greater volume of applied science coursework allows less time for this to happen.

8.5 Male and female coursework and examination attainment 2006-7

To build upon the evidence from 2005/6 concerning differences in male and female attainment in coursework and examination study, an analysis of boys and girls coursework and examination scores was undertaken in 2006/7. Table 8.6 displays the results of the 2006/7 analysis.

Table 8.6 T-test results for male and female coursework and examination attainment 2006-7

Test	df	N	Sd	Result
Applied science male/female coursework	170	172	11.65	0.012
Applied science male/female exam	170	172	12.52	0.67
Applied male coursework/exam	86	88	10.22	0.42
Applied female coursework/exam	82	84	13.87	0.011
Modular science foundation male/female coursework	36	38	15.74	0.83
Modular science foundation male/female exam	36	38	9.28	0.45
Modular science foundation male coursework/exam	40	42	14.92	0.003
Modular science foundation female coursework/exam	32	34	13.58	0.036
Modular science higher male/female coursework	8	10	5.12	0.057
Modular science higher male/female exam	8	10	6.94	0.96
Modular science higher male coursework/exam	8	10	10.50	0.0063
Modular science higher female coursework/exam	8	10	12.56	0.0001

*<p.05, **<p.01, ***<p.001 (using Bonferroni correction)

Table 8.6 highlighted no significant differences, nor any close to the critical level

8.5.1 Analysis of results data

T-test data revealed no significant results for boys and girls scores at exams and coursework in any specification, all values being well below the critical value. These results concurred with those from the previous year and differed from Woodfield, Earl-Novell and Solomon's (2005) assertion that female students outperformed males at coursework and examination scores, as in all specifications, there were no significant differences between boys and girls exam and coursework scores. Woodfield, Earl-Novell and Solomon's (2005) research was conducted with undergraduate results, but still provides evidence of variation in male and female examination and coursework scores.

I can conclude that in the 2006-7 year, as with 2005-6, for the main school of this study, there were no significant differences between boys and girls coursework and examination scores, nor were there any results close to significant levels.

8.6 Coursework and examination attainment 2007-8

In this academic year a large number of separate science students opted not to take their exam, relying instead on examinations they took in year ten. Therefore I included these results for the separate science data, rather than rely on a small amount of data in 2007/8. These specifications were of the old modular style, but I included them as a comparison to applied science and science 2006 that reflected the number of pupils who gave their opinions in the other sections in 2007/8 and is more representative of them than a small number of results in this academic year. It also allowed for a direct comparison between the new, old and applied forms of coursework.

Table 8.7 displays the numbers of students in the different specifications that were analysed.

Table 8.7 2007-8 Analysis cohort

Subject	Number of boys	Number of girls	Total number of pupils
Applied science	10	31	41
Separate science foundation	13	15	28
Separate science higher	14	9	23
Science 2006	68	58	126
Total	105	113	218

Table 8.8 displays the results of the t-test analysis of coursework and examination grades in the different specifications, with a null hypothesis of no significant difference between coursework and examination scores.

As in 2005/6 and 2006/7, significant differences were uncovered with the specification taken by the more able or motivated science learners. Separate science students, at foundation and higher level achieved significantly better coursework than examination scores at the 0.001 level. Science 2006 learners were found to achieve significantly better examination than coursework grades at the 0.01 level.

Table 8.8 T-test results for coursework and examination attainment 2007-8

Test	df	N	Sd	Result
Applied coursework and exam grades	80	82	11.82	0.22
Science 2006 coursework and exam grades	250	252	13.36	2.64**
Separate foundation coursework and exam grades	54	56	12.66	9.17***
Separate higher coursework and exam grades	44	46	20.53	8.71***

*<p.05, **<p.01, ***<p.001 (using Bonferroni correction)

8.6.1 Analysis of the 2007-8 data

Science 2006 shows a different, and significant, result. Examination scores were significantly higher than those for coursework. T-test analyses found this to be significant at the 0.01 level, indicating a one in 1000 chance that the result was due to chance.

The ISA coursework was introduced not long before this academic year, and as teachers and pupils were both new to the concept, the former in particular were less aware of how to teach the coursework for pupils to achieve good results.

The results from the separate science pupils revealed significant differences at the 0.001 level in favour of coursework at foundation and higher levels. Possibly, pupils and teachers had become more aware of what is needed to achieve good results. Field note evidence may agree with this:

> 'We get better at teaching the coursework because we realise what works and what doesn't, we know what exactly is needed for them to pass and what isn't' (SIT3 15/05/2008)

In 2007/8, in the main school of this study, separate science students achieved significantly better coursework than examination scores. Science 2006 students achieved significantly better examination than coursework grades.

8.7 Male and female coursework and examination attainment 2007-8

Table 8.9 displays the results of the 2007/8 t-test analysis for boys and girls coursework and examination scores.

Table 8.9 T-test results for male and female coursework and examination attainment 2007-8

Test	df	N	Sd	Result
Applied science male/female coursework	80	82	8.43	0.57
Applied science male/female exam	40	82	14.38	0.07
Applied male coursework/exam	18	20	5.98	0.18
Applied female coursework/exam	24	26	12.98	0.1
Science 2006 male/female coursework	124	126	14.73	0.28
Science 2006 male/female exam	124	126	10.55	0.09
Science 2006 male coursework/exam	134	136	14.48	1.34
Science 2006 female coursework/exam	114	116	11.98	0.04
Separate science foundation male/female coursework	26	28	7.67	0.86
Separate science foundation male/female exam	26	28	8.18	0.19
Separate science foundation male coursework/exam	24	26	13.08	1.36
Separate science foundation female coursework/exam	28	30	12.45	8.74***
Separate science higher male/female coursework	21	23	19.71	0.92
Separate science higher male/female exam	21	23	10.28	0.48
Separate science higher male coursework/exam	26	28	16.11	6.53***
Separate science higher female coursework/exam	16	18	26.50	0.015

*<p.05, **<p.01, ***<p.001 (using Bonferroni correction)

The results from table 8.9 clearly show no statistically significant differences between boys and girls coursework scores. Two significant differences were uncovered; between separate science foundation female coursework and exam scores at the 0.001 level, and between separate science male higher coursework and examination scores at the 0.001 level. In both cases, coursework scores were significantly higher than examination scores. The science 2006 boys' coursework and examination t-test scores were the closest non significant results to the significant figure at the 0.05 level, with examination scores higher than those for coursework.

8.7.1 Analysis of results data

The null hypothesis; that there are no significant differences between boys and girls coursework scores and boys and girls examination scores for both applied and modular science is, again, correct. The t-test data from the separate science students were the only tests to outline significant differences in girls and boys results data. Both significant results were between coursework and examination grades, pinpointing higher achievement from both boys and girls in coursework than exams, rather than significant differences between the sexes, continuing a trend shown by overall modular results in 2005/6 and 2006/7, and separate sciences in 2007/8, which had significantly higher coursework than examination grades.

The result for science 2006 boys' examination and coursework scores was close to the critical level, and although not significant, indicates a better performance at examinations, where they achieved a mean score of 57%, and coursework, where they achieved 44%. This has similarities with the overall result for science 2006, where students achieved significantly better examination scores at the 0.01 level.

Overall, I can conclude that in the three years, at the main school of this study, there have been no significant differences between the boys and girls coursework and examination data, although there were indications that both sexes were achieving better coursework scores in the modular and separate sciences, and that boys in science 2006 had achieved better examination than coursework scores.

8.8 Overall conclusions

Some of the data points to a significant difference between coursework and examination scores in specifications where coursework can be improved. Significant differences were found in modular and separate science from 2005-8, with coursework grades significantly higher in each case. This trend was more prevalent in the higher level of modular and separate science, with t-test results showing less likelihood that the results were due to chance. In each of these courses, coursework has been able to be improved to individual targets. Many pupils who studied modular, separate and applied sciences indicated in interviews (section 5.8) that they felt confident in using self assessment to improve their work (as the QCA (2006d) claimed to be a part of AfL) unlike many of their science 2006 counterparts. In addition, observational analysis (chapter six) showed more pupils making meaningful constructs through coursework. This was highlighted in the 2005/6, 2006/7 and 2007/8 analyses. The results consistently showed that pupils showed interest, offered scientific ideas, restructured new ideas and applied them to a greater degree in coursework lessons than in exam learning lessons. An exception was science 2006 in 2007/8 where pupils learned more constructively through classwork.

Although applied science students indicated a preference for coursework and learned more constructively through it, their results, although on average higher for coursework than examination (for example 54.1% for coursework in 2006/7, 49.8 for examination), were not significantly better. This may be due to the higher amounts of coursework that applied science students have to do, which leaves less time for students to improve on their work. In some cases, students who miss time at school, for example due to illness, may need time to catch up on missed coursework, rather than improve it, whereas examination learning and revision, where experimental results are not needed, can be done at home.

Science 2006 students in 2008 showed significantly greater attainment in examinations than in coursework. This was also apparent, although not significantly, in the boys, but not girls, science 2006 examination and coursework scores. A questionnaire by Rogers and Hallam (2006) indicated that overall boys were more positive about examinations than girls, and these results would indicate that this may be borne out in terms of science 2006 scores in this year. Both Rogers and Hallam (2006), and the DfES (2006b) found boys preferred examinations, as they defined what they needed to learn and were able to revise in short bursts. Perhaps the new form of coursework, the ISA, has not been fully understood by teachers and pupils alike, and it will take time to uncover how to increase grades in it. The fact that individual pieces of coursework cannot be improved may have affected results, even though pupils could complete a number of ISAs, only submitting the best marks. In 2007/8, Science 2006 students were less likely to prefer coursework to examinations (section 4.6) than students who studied applied or separate science.

In applied and separate science, many pupils were able to improve their coursework to targets agreed by themselves and their teachers, in order to improve their grades. This is what Black and Williams (1998) described as assessment for learning. When asked if they were able to tell what grade their coursework was at and how to improve it (chapter four), more applied and separate science students indicated that they could, (41% and 39%) than those studying science 2006 in 2006/7 (22%). Conversely, more science 2006 students indicated that they could not improve their work (22%) when compared with applied (15%) and separate science students (3%). Interview data (chapter five) indicated that in terms of assessment for learning, many applied, modular and separate science pupils felt confident in using self assessment to improve their work (as the QCA (2006d) claimed to be a part of assessment for learning). Science 2006 pupils were less likely to state that they could use assessment for learning. In all of the specifications of this study (chapter five) with the exception of modular science in 2005/6, many pupils indicated that they learned more through coursework than examination work. In the courses where more pupils have indicated that they can improve their coursework, there have been significantly higher coursework marks than those for examinations, in the main school of this study.

In modular science in 2005-6, and 2006-7, separate sciences in 2007-8, applied science in 2005-8, and science 2006 in 2007-8 there were no significant differences between boys and girls coursework, and examination scores, using t-test analysis. Therefore, I can conclude that in the main school of this study, the data shows no significant differences between boys and girls coursework and examination results in applied science, science 2006, modular science and separate sciences from 2005-8. This does not agree with the findings of Elwood (1999) who found that in modular science, girls achieved significantly higher coursework scores than boys, at the 0.05 level. There were no t-test results close to the significant levels in any of the boys' and girls' t-test results with the exception of science 2006 boys' examination and coursework scores, which I have discussed previously. Questionnaire data (chapter 4) revealed few differences between boys and girls views in preferring coursework to examinations. However, girls were more likely to be stressed by coursework and examinations than boys (chapter 4). Thus increased anxiety and stress, in this study, are not linked to any difference in attainment.

I had the opportunity to teach a small group of disruptive boys as a single sex class, thus providing a small amount of data on the subject. Despite previous behavioral problems, they were able to achieve grade C passes at their applied science coursework (appendix

13). This was higher than their predicted grades. The small size of the group, alongside the absence of other pupils to play up to, which was considered a cause of boys' underachievement (DfES 2006b), played a considerable part in their successes. The pupils saw the reasons for their achievement thus:

> 'Dunno why we worked so well' (S1C5P3 09/05/2007)

> 'Probably 'cos it was a small group, not 'cos we didn't have girls' (S1C5P4 09/05/2007)

This exchange of views hints that factors such as class size, rather than whether the class contains boys or girls, may well have a greater bearing on performance.

Having considered the statistical analyses of the different science specifications, alongside the interview, questionnaire and observational data of the previous chapters, the proceeding chapter considers conclusions that can be drawn from the information. It also includes an analysis of the research questions that guided this research, how they were answered, and a series of statements outlining the main findings.

Chapter 9

Discussion and conclusions

9.1 Introduction

This study set out to research pupil and teacher perceptions and attitudes concerning science coursework and examinations and how pupils learn in science with particular reference to constructivism, active learning and assessment for learning. This was complemented by examining differences in attainment in coursework and examinations through the different specifications offering GCSE science courses. The data has been used to evaluate the effectiveness of GCSE science within the National Curriculum.

In order to do this, I undertook a case study focused on one school, and drawing on complementary data from local schools, over a period of three academic years. This time period was significant, as it encompassed the removal of the established GCSE double science specification to be replaced by science 2006. At the same time applied science was introduced as a more vocational coursework based option and many more scientifically minded students began to study for separate GCSE qualifications in each of the sciences. In my workplace, two teaching groups of pupils chose this option.

The four questions that guided my research were:

1) What are the perceptions and attitudes of key stage four pupils and teachers towards GCSE science assessed coursework?

2) What are the variations in attainment between GCSE science coursework and examination study?

3) How do pupils learn from GCSE science coursework and examination study?

4) How effective, in terms of examination grades, is GCSE assessed science coursework for pupils' learning within the National Curriculum?

In the methodology section (chapter 3) the research methods I used were introduced. These were the pupil questionnaires and interviews, pupil learning style observations, teacher interviews, field notes and quantitative analysis of data. Each was designed to contribute to answering the above questions.

9.2 Summary of the main findings

Processing and analyzing the data in chapters four to nine have allowed me to reach the following main findings:

- **The pupil questionnaire:** More pupils preferred coursework to examinations; they were generally not sure if they liked doing coursework, they worked quite hard and got stressed but not as much as for exams. Girls tended to be more stressed over coursework and exams than boys. Pupils were not all sure they had the correct amount of coursework and they were not sure if they could apply assessment for learning techniques in order to improve it. One class achieved significantly better grades by doing their coursework over one day (chapter four).
- **The pupil interviews:** Applied and science 2006 pupils were most enthusiastic about coursework. Overall many pupils felt that they learned, and achieved more by completing coursework than by studying for examinations, with the exception of science 2006 students. Pupils generally felt that they learned best through experiments and practical work. Applied, modular and separate science students felt more able to apply assessment for learning, in terms of using peer, self and teacher feedback to improve their work than their science 2006 counterparts (chapter five).
- **The pupil learning approach observations:** Learning disposition analysis indicates that coursework based lessons produced more expressive, productive, innovative and constructive work amongst most pupils. The differences were more pronounced in modular than applied science pupils. However, science 2006 pupils in 2007/8 tended to learn more constructively through classwork. Exam study, in general, gave less scope for teamwork, innovation, flexibility and constructive learning with an emphasis on learning for one's self rather than sharing results and working together to process conclusions (chapter six).
- **The teacher interviews:** Teachers had to give some pupils a great deal of help in order to complete some pieces of coursework. They became generally happier with assessment for learning in coursework through the duration of this study, but some did not welcome the coursework section of science 2006 (chapter seven) and the lessening of AfL opportunities that science 2006 entailed. In terms of constructivism, some teachers used pupil ideas in planning, but others considered that only more able or motivated pupils gained a meaningful understanding of science and applied scientific ideas out of the lab.

- **Field notes:** Some pupils spoke of the benefits of coursework in terms of 'getting all the marks' whilst others bemoaned the workload and their lack of interest in it. Other pupils spoke positively of the science they have learned through constructivism. They believed that teachers valued their ideas and that they could relate their science to everyday life. Some teachers were unsure of the nature of constructivism and were more inclined to teach the 'facts' for examinations. Others were critical of the time needed to mark science 2006 coursework.
- **Quantitative analysis:** There were no statistically significant differences between boys and girls exam and coursework grades. Coursework grades in modular and separate sciences were superior, in many cases significantly, to exam grades. This was more apparent for learners who took the higher level specification. Science 2006 students achieved significantly better grades in exams than in coursework. Applied science grades were overall better for coursework than examinations, but these results were not statistically significant (chapter eight).

Within the next section I will discuss in detail the findings I have reached and link these to the review of relevant literature in chapter two. To conclude I will reflect on the research, contemplating the strengths, weaknesses and limitations of my study, suggesting ideas for further studies.

9.3 Discussion of the main findings

I have placed the findings of this research as a series of conclusions, relating to each research question in turn, and linking the conclusions to the relevant literature.

9.3.1 Research question one: What are the perceptions and attitudes of key stage four pupils and teachers towards GCSE science coursework?

Over 60% of respondents to my questionnaires indicated a preference for coursework over exams. This agreement continues from GCSE into higher education; a majority of university students answering Woodfield et al.'s questions (2005) expressed such a preference.

Overall, pupils were not sure if they liked doing coursework, yet they worked quite hard and were stressed by it, but not as much as for exams. There is still an issue of less motivation in secondary students than in primary students for science according to Naylor and Keogh (2001), Ofsted (2000) and Murray and Reiss (2005). The factors that motivate individual students are myriad, as discussed in section 2.4.6, and I would reason that they are as individual as the constructs that each pupil has of the subject.

Many students felt that they learned, and achieved more by completing coursework than by studying for examinations. This compares favourably with Murray and Reiss (2005) who found only 32% of students found (pre applied/2006) investigative science to be useful and effective, and 50% enjoyed it. Most students thought that they received enough coursework but they were not sure if they could apply assessment for learning techniques (including self assessment, peer assessment, teacher written and verbal feedback) in order to improve it. However, within this assertion, more applied and separate science students felt able to apply assessment for learning techniques to their coursework than their science 2006 counterparts. Teachers tended to agree with this, with an interviewee in 2007/8 mentioning that AfL can be used in applied science, but not science 2006. Interviews found one group of separate science learners (section 5.9) who specifically mentioned teacher feedback in helping them with their coursework.

The significance of assessment for learning in the classroom was highlighted by Fuchs and Fuchs (1986). They found that such assessment techniques led to significantly increased school achievement. More recently, McDonald and Bould (2003) found that applying assessment for learning led to significantly higher examination scores, at the 0.01 level. Their study involved significant training to pupils in AfL techniques and led to a very positive response from students, In this study, many applied and separate science pupils felt able to assess and improve their coursework. Some pupils mentioned that time constraints may hinder the process.

Many pupils spoke in interviews of the benefits of coursework, some mentioning the lack of stress and the help they receive from teachers. Jones et al. (2000) had similar results. 79% of the GCSE science pupils in Northern Ireland they interviewed stating that they had learned through coursework. This can be viewed alongside Gibbs and Simpson's (2004) assertion that undergraduates were more likely to remember what they had learned through coursework than examinations. This differs from Toplis and Cleaves's (2006) findings that 'pupils are experiencing a divorce of science investigations from learning' (p. 77).

Some students had a tendency, in this study, to bemoan their workload and express the lack of interest they have in it. Some respondents in the 2006/7 interviews decried coursework as being 'bad' or 'boring'. A field note quote from an applied science pupil in a coursework lesson sums up this viewpoint:

> 'It's boring Sir [coursework], there's too much work to do, it just goes on and on' (S1C3P20 13/01/2007)

Pupils tended to be overloaded with coursework, according to Bishop, Bullock, Martin and Thompson (1997). However in Jones et al.'s (2000) study only 11% expressed negative views, mostly in copying up and handing in the work. The negative responses from my 2006/7 questionnaire reached 37%.

In my study many students of both sexes preferred a coursework based approach. Woodfield et al.'s (2005) study found that neither sex had a preference for examination or coursework as a means of assessment. A majority of boys and girls liked to think that they did not find coursework a stressful experience.

A study on male and female coursework attainment at university level (Woodfield, Earl-Novell and Solomon 2005) found that:

> Students of both sexes claimed they believed coursework to be a fairer measure of actual educational achievement as it tested their knowledge and broad analytical abilities better than examinations, which they felt primarily tested their powers of recall and their ability to withstand extreme pressure (p.41).

This has similarities with my findings from the whole afternoons / morning coursework questionnaires (section 4.3.2) where 70% of respondents preferred coursework to examinations and not one response expressed a preference for exams.

There were differences in the results for exam stress. 81% of girls in 2005/6 agreed that exams did cause them stress. This compared to 51% of the boys, suggesting that a much lower percentage of boys had admitted to feeling exam stress. More girls (47%) than boys (32%) in 2007/8 agreed they were stressed by coursework. The numbers were 34% of boys and 44% of girls in 2005/6. Alongside this, 73% of girls agreed, and 51% of boys agreed they got stressed by exams in 2006/7. 69% of girls agreed as did 49% of boys in 2007/8.Boys were found to be more positive about examinations and less anxious about them, the latter significantly, in a study by Rogers and Hallam (2006). Woodfield, Earl-Novell and Solomon (2005) noted a higher degree of anxiety over academic issues amongst women undergraduates. Field note evidence (section 5.2.1) indicates that some girls believed that their greater concern about getting good coursework marks contributed to their not liking it. These results indicate that, at least in this study, this anxiety may start well before university. It was reported that many 'exam-phobics' tend to be women under the age of 21 but that 'women were not disproportionately represented within the group' (Woodfield et al. 2005 p.6), and that women made a number of positive comments about examinations. Increased anxiety and stress, in this study, are not linked to any difference in attainment, as I uncovered no statistically significant differences between boys and girls coursework and examination attainment.

Despite the assertion by Ofsted (2004) that little data on the topic of male and female success in single sex classes within a mixed school exists, I was able to teach a small class of low achieving boys. All of them achieved a C grade at their coursework (appendix 13) despite some being predicted far lower. They all considered that their success was due to being in a small group, without elaborating on why this was important. Grayling (2006) considered that mixed sex classes caused disruption for boys and girls. The views of the boys in this class disagree with this, with field note quotes such as:

> 'Probably 'cos it was a small group, not 'cos we didn't have girls' (S1C5P4 09/05/2007)

My personal opinion is that, in general, pupils, who are disruptive, whether they are boys or girls, are harder to control in a larger class where more peers can notice their behaviour. In a small class situation, however realistic this may be in schools, they have fewer people to play up to and more personal attention with which to complete their work. Due to timetabling and setting issues, a comparison study of a girls group was not possible.

Many teachers, in this study, believed that pupils were given a lot of help in order to complete some pieces of coursework. Similar sentiments were expressed by teachers to Jones, Gott and Jarman (2000). They became happier with assessment for learning (in terms of pupils improving their work from peer, self and teacher feedback) in coursework through the duration of this study. Assessment for learning does include activities undertaken by teachers, as well as students, to modify learning (Black and Williams 1998) so it is important that where AfL is used to improve pupil work, teachers are actively involved. Research conducted by Black and Williams (1998) found that the more competent and confident a teacher was at using AfL, the greater the effect of AfL on pupil attainment.

Some teachers did not welcome the coursework section of science 2006, although field note evidence from one teacher pointed out that:

> 'Science 2006 coursework is all done and dusted in one go, it saves on the remarking and handing out and taking back again and again and the loss of coursework that characterised the old models' (S1T1 15/03/2007)

Another teacher felt that students found the coursework straightforward to complete, and easier to mark (section 7.6).

Science 2006 pupils in the 2006/7 and 2007/8 interviews often had a negative opinion of science coursework. Only one group of pupils offered a positive opinion, considering how the coursework helped them prepare for their exams.

Some teachers took a less positive view of science 2006:

> 'The results are really poor for all groups. The work can't be improved on' (S1T4 06/03/2007)

The latter quote outlines the lack of assessment for learning opportunities in science 2006 coursework, which was commented on by a number of teachers in the 2006/7 and 2007/8 interviews.

Some teachers indicated that coursework only teaches pupils the skill of copying, if it teaches any skills. Jennings (1992) noted that pupils can copy when they complete the same task. This was a commonly held view in the 2005/6 interviews, but lessened somewhat afterwards. This concurred with the views of two girls who indicated that coursework was easier to cheat in their 2005/6 interviews. One described how coursework meant 'copying work' whilst the other wrote that copying 'could be cheating'. As Jennings (1992) noted, pupils can copy when they complete the same task. 2005/6 was the last year of modular coursework. In the following years of the questionnaire, no pupils mentioned cheating. Cheating has been linked to extrinsic goals, such as overall exam results by Anderman, Griesinge and Westfield (1998), who found no gender link to cheating, although they commented that cheating was common amongst teenagers, citing a questionnaire in which 39% of respondents admitted to having done so at school. Although coursework cheating was not explicitly mentioned in the questionnaires and interviews used in this research, only two pupils in three years chose to mention it as a concern. Many teachers working with the old modular scheme complained of having to give a great deal of assistance to pupils when writing coursework. By 2007/8, with the advent of science 2006, that help was less overt although many teachers still admitted to giving a lot of assistance.

I would suggest that the science 2006 coursework, introduced in 2006, which is less easy to plagiarise has led to this demise. As Williams (2001) pointed out 'there will be no choice for the education system other than to retreat into traditional methods based on terminal supervised exams' (p238), which is partly what has happened with science 2006 coursework. Previous research found a number of teachers complaining about how much pupils needed leading to do investigative work and of how little they gained from coursework (Jones, Gott and Jarman 2000). Despite this, over the time of this research, teachers became generally more positive in their views of whether coursework builds pupil ability: In 2005/6 as modular coursework was phased out the answer was definitely 'no'. In 2006/7 and 2007/8 opinions had changed, with some teachers noting pupils developing practical skills and seeing progression in their work.

McAteer (1998) commented that GCSE science was based on getting answers that fit with a pre taught theory. These pieces of evidence indicate that coursework followed a prescribed method to get almost prescribed results, which did not fit a real scientific model of investigation as proposed by Feyerabend (1975) and Medawar (1982).

Many teachers criticised the moderation process. In my interviews, some teachers found it difficult, tedious and time consuming. In a questionnaire by Jennings (2000) some teachers indicated that they were unhappy with the marking and administration of coursework. Others had no problem with it. In the National Endowment for Science, Technology and the Arts (2006) poll, many teachers considered that time was considered the main constraint in teaching coursework. The QCA (2005) found that 50% of 138 science teachers considered coursework a valid means of assessment, yet 45% disagreed. The same survey found time and validating coursework to be important issues.

Field note evidence uncovered some disagreement with Gott and Roberts' (2006) assertion that using the written ISA tests would be more efficient, and free up more time for teaching:

> 'They take slightly less time but not much, but the marking takes a lot longer, there is a less prescriptive mark-scheme, so it doesn't free up any time to plan teaching' (S1T1405/05/2008)

> 'Whatever way you look at it, marking takes a long time...Not the easiest things to mark' (S2T12 02/03/2009)

Professional development for teachers needs to be tailored to meet subject needs, including the assessment of coursework, rather than whole school issues. As one colleague pointed out:

> 'I've never done a useful CPD session in a school in my teaching career' (S1T11 03/10/2007)

Marking, setting and teaching coursework and investigative skills should be an essential part of science professional development as it encourages unity and gives confidence in marking and moderating, although there were few negative comments about this area in the 2006/7 interviews.

9.3.2 Research question two: What are the variations in attainment between GCSE science coursework and examination study?

There were no statistically significant differences between exam and coursework grades between boys and girls in this study (chapter eight).

The above findings share similarities with the Ofsted (2004) investigation into gender differences where combined and separate science subjects were found to have only very slight differences between the sexes (table 2.5). This is evidence that the single sex classes suggested by Younger and Warrington (2005) are not needed, at least in science, as attainment levels for both sexes are similar.

There is evidence that boys perform worse at GCSE sciences than girls, apart from in physics (Ofsted 2004) and the factors contributing to this are many, including the DfES (2006b) view that peer group pressure, whereby boys behave disruptively to gain support from their peers, influences young male behaviour. They also argued that girls tended to achieve more in open ended process based work, whereas boys tended to shine in memorizing rules and concepts that need to be remembered quickly. In 'questions that involve the retrieval of declarative knowledge' boys achieved better results in physics questions, girls at biology, according to (Bell 2001 p.485). Boys' grades were higher at problem solving in science, according to research in Scotland by Powney (1997). The results of Bell's (2001) study were attributed to many boys preferring the impersonal data of physics and girls preferring the personal nature of biology, particularly human biology, without offering data to support this assertion. Bell (2001) ascribed the findings to 'differences in the types of activities boys and girls prefer to engage in and the environments made available to them by parents and peers' (p.484). This affects the ability of a pupil to retrieve scientific knowledge from an exam question and link it to what is asked for in the answer. Research in the USA found that many girls considered science not relevant to their ambitions and uninteresting (Millar, Slavinski-Blessing and Schwartz 2006). Boys, overall, showed a preference for sciences and mathematics. The only exception was biology, which was the only science subject girls found interesting. Millar et al. (2006) attributed this to the subject being a people orientated and helping science. This agrees with Bell's (2001) assertion that girls tended to prefer the personal nature of biology. As modular, applied and science 2006 all contain aspects of biology, chemistry and physics, all of these specifications contain aspects of impersonal and personal data. However, as chemistry and physics make up two thirds of the content of these specifications, it could be argued that as the impersonal data preferred by many boys (Bell 2001) is predominant in GCSE science, then, overall, boys should achieve more than girls.

Data from Ofsted (2004) however showed the difference in science GCSE grades between boys and girls to be lower than in many other subjects and indeed boys were better at GCSE physics. Powney (1997) had earlier found that in the Scottish educational system, girls tended to outperform boys at science coursework. More recently, Hallam and Rogers (2006) stated that since 1994, there was no evidence of increased improvement by boys, or worse performances by girls, in GCSE subjects where the coursework component was reduced to 20%.

There was a perception, according to Elwood (1999) that girls performed better at GCSE coursework. My data uncovered no statistically significant differences between boys and girls coursework and examination scores, in all of the specifications. This was despite in 2005/6 a lower number of boys than girls claiming to get stressed about exams, and a lower number of boys claiming to get stressed over coursework. There were similar results in the following years. Elwood (1999) also found that girls achieved higher coursework grades than boys, with the difference in mean scores significant at the 0.05 level. My data uncovered no significant differences between boys and girls coursework scores. There was one result close to the significant figure, which was for boys' coursework and examination scores in science 2006 in 2007/8, where boys had higher examination scores. Research by Rogers and Hallam (2006) found more boys to be more positive about examinations than girls, as they defined what they needed to learn and were able to revise in short bursts. The DfES (2006b) came to similar findings. Another finding from Elwood (1999) was that although boys scored less at coursework, there was more spread amongst their marks, which led to coursework having more of an effect on their overall grades.

There were two significant results in 2007/8. They were for boys higher, and girls foundation separate science examination and coursework grades, with both sexes achieving significantly higher coursework scores. This is additional evidence for higher achievement from both boys and girls in coursework that can be reviewed and improved over exams, rather than any significant differences between the sexes.

Looking at the specifications rather than the sexes or lesson timings, the following results occurred: Coursework attainment in all forms of science was greater than that in examinations in the 2005/6, 2006-7 and 2007-8 academic years with the notable exception of science 2006 coursework. In 2007-8, the first year results were collated for science 2006, examination scores were 5% higher than those for coursework. T-test analysis found this to be significant at the 0.01 level. This was possibly due to the new, tested nature of science 2006 coursework. It will take time for teachers to ascertain how to teach for pupils to achieve the best results.

Coursework grades in applied and modular /separate sciences were superior, in many cases significantly, to exam grades, particularly for learners who took the higher tier of the specification. Applied science coursework grades tended to be higher than those for examinations, but not significantly so. In 2005/6 applied science coursework marks were, on average, less than 1% higher than exam marks. This compared with around 5% for modular science foundation and close to 20% for the higher. In 2006-7 the figures were 5%, 12% and 18% respectively. In 2007-8, the figures were 3% for applied science, 16% for separate foundation, 25% for separate higher, but 5% in favour of exams for science 2006 Therefore, in this study, specifications with less coursework had better coursework grades, with the exception of science 2006. It could be inferred that the less the coursework, the better the grades attained, provided that the coursework is not the science 2006 ISA. There is, however, no research in the extant literature with which to compare these findings.

There was one significant difference in 2005-6: a highly significant t-test between modular higher coursework and exam scores. In 2006-7 there were similarly significant results including a very significant t-test between modular foundation coursework and examination scores, and a highly significant t-test between modular higher coursework and examination scores. In 2007-8, there was a highly significant t-test between separate science foundation coursework and examination scores, and a highly significant t-test between separate science higher coursework and examination scores. However, there were no significant results for applied science and none close to the critical figure, pinpointing better, but not significantly so, grades at coursework.

In applied and separate science, pupils were able to improve their coursework to targets agreed by themselves, their peers and their teachers, in order to improve their grades. This is part of what Black and Williams (1998) described as assessment for learning. Research by Williams, Lee, Harrison and Black (1994) and McDonald and Bould (2003) have shown assessment for learning to improve pupil results. When pupils were asked in 2006/7 if they were able to tell what grade their coursework was at and how to improve it (chapter five), many applied and separate science students indicated that they could, however, a higher number of science 2006 students indicated that they could not improve their work. Interview data highlighted that in terms of assessment for learning, many applied, modular and separate science pupils felt more confident in using aspects of assessment for learning to improve their work than their science 2006 counterparts. Observational analysis showed more pupils making meaningful constructs through coursework. This was highlighted in the 2005/6, 2006/7 and 2007/8 analyses. The results consistently showed that, overall, pupils showed interest, offered scientific ideas, restructured new ideas and applied them to a greater degree in coursework lessons than in exam learning lessons. A teacher interviewed in 2007/8 agreed that a coursework based approach helped students to understand science (section 7.9). An exception was science 2006 in 2007/8 where more pupils learned more constructively through classwork. Alongside this, in terms of active learning, more pupils tended to be confident creative, adventurous and responsive in completing their coursework. Therefore in this study, learning through coursework for most pupils is more constructive active, and incorporates more assessment for learning than for examinations, with the exception of science 2006.

In all of the specifications of this study, with the exception of modular science in 2005/6, a majority of pupils indicated that they learned more through coursework than examination work. In the courses where more pupils have indicated that they can improve their coursework, there have been significantly higher coursework marks than those for examinations, in the main school of this study.

This leads me to conclude that, in this study, more students who study a specification with a coursework component that can be improved over time using assessment for learning achieve better grades for coursework than for examinations. This is more prevalent in learners taking the higher tier of that specification. They also show more elements of constructivism in their learning. It was pointed out by Pouchaud (2005) that many schools have used applied science to target C/D grade borderline pupils (applied science pupils in 2005/6, 2006/7, and 2007/8 achieved higher coursework than examination scores, but not significantly so). As coursework comprises a large proportion of the course, using applied science would seem to be effective at boosting achievement through coursework, but not to a significant extent, as specifications with lower coursework content, but that coursework can be improved, show significantly higher levels of coursework attainment than examination.

To sum up, in this study, boys and girls do not have significantly different scores at coursework and examinations. Specifications with less coursework produced better coursework grades, provided the coursework could be improved and remarked over time. The more able science pupils tended to achieve a bigger difference between coursework and exam grades than did their less scientifically inclined peers, although these pupils did score significantly better at their coursework. This indicates that, overall in this study, being more able, and being able to improve a smaller amount of coursework led to better grades at that coursework. A lack of extant literature on this topic would indicate that further, and more extensive research would be needed to determine whether this is a localised, study specific conclusion, or one that has wider applicability.

9.3.3 Research question three: How do pupils learn from GCSE assessed science coursework and examination study?

There are many ways of defining learning but for research question three I focused particularly on constructivism, assessment for learning and active learning. All of which I believe are meaningful for understanding the effects of examination study and coursework.

Learning disposition analysis shows that coursework-based lessons tended to produce more expressive, productive, innovative and constructive work amongst pupils. The differences were more pronounced in modular than applied science pupils. Exam study did not give such scope for teamwork, innovation, flexibility and interdependence with an emphasis on learning for one's self rather than sharing results and working together to process conclusions.

This was an important finding of all of the analyses. The results consistently showed that pupils generally showed interest, offered scientific ideas, restructured new ideas and applied them to a greater degree in coursework lessons than in exam learning lessons. This could have been due to the need for coursework to be completed to the highest standard within a small time framework in order to gain good marks.

The results firstly showed a greater degree of interest and offering scientific ideas amongst learners, yet less ability to restructure and apply new ideas given by the teacher. Perhaps pupils tended to lose the impetus that they built up early in lessons. However in the second and third year of the study, restructuring and application in almost all subjects was at a similar level to that of interest and ideas. The implication was that pupils and teachers became more adept at using and applying scientific ideas, particularly in the new specifications in the school of this study. When teachers were asked about the use of assessment for learning techniques (chapter seven) some felt that although they gave feedback comments, pupils would not apply them. However, many pupils were showing an ability to restructure new scientific ideas which demonstrates them being able to review their existing knowledge and build upon it.

When pupils have the opportunity to write scientific thoughts in their own words, it is beneficial to their learning, and enjoyable for them, according to Woolnough, McLaughlin and Jackson (1989).This did not happen with the separate sciences in 2007/8 where pupils used to the older modular coursework were faced with learning the new science 2006 form of coursework which themselves and teachers were less adept at teaching and completing.

Overall, science 2006 students by 2007/8 were more productive and innovative in their coursework lessons, but they were as expressive, confident and skilful at evaluating in classwork lessons. Through constructivism, they showed more interest in their ideas, and were better at eliciting and restructuring them with teacher help in theory lessons, which was the reverse of the previous year. Perhaps the importance of examinations and increased teacher skill and confidence in teaching the theory, but not the coursework, for the new specification, caused this. Another factor has been a lack of opportunities for pupils to improve their work through self review and teacher feedback. The conceptions that teachers bring to their lessons can shape the constructivist nature of them, according to Driver and Bell (1986). A positive concept of science 2006, after a year of teaching it, could influence the degree to which constructivist learning takes place.

In terms of active learning, in which work has individual importance to each pupil (Black and Harrison 2004), there was a similarly higher overall level of learning for coursework. I noted pupils being confident creative, and responsive in their work although there were some discrepancies between the specifications. In both the separate and the applied sciences in 2006/7, and science 2006 in 2007/8, pupils tended to show a greater degree of confidence and curiosity when dealing with exam study. Science 2006 was the only specification to have statistically significant results in favour of examination study over coursework (chapters eight). There was a possible reaction to the sheer volume of coursework in applied science (which did not achieve statistically significant coursework to examination scores), and the need to learn for examinations, which constituted a far greater percentage of overall separate science grades. There may be a possible tipping point where a certain volume of coursework causes a significant percentage of learners to lose motivation and interest.

Pupils learn in GCSE science coursework and examination in a variety of ways. For pupils when asked how they learned best in science, practical work and experiments proved to be popular choices (section 5.11). Practical work allows pupils to build on their procedural knowledge (Gott and Duggan 1999) wherein they develop skills including measurement, experimental design, and the validity and reliability of tests. These latter skills are incorporated in the science 2006 coursework (AQA 2005b). Procedural skills are also incorporated in applied science coursework (AQA 2005a), and formed a part of modular coursework, particularly the obtaining evidence section (AQA 2004b). The preference by some students for practical work could be due to a genuine preference for learning through practical work, or the opportunity it allows for students to work independently in a kinaesthetic way that theoretical science does not allow.

Children can learn actively. Active learning 'has to be done by them (the pupils), it cannot be done for them' (Black and Harrison 2004 p.4). It is the idea of work having individual importance to the pupil and their findings, results, conclusions and ideas being of value, consistent with research by Tytler (1992) and Woolnough 1994). The 'benefits of making science relevant to pupils and of engaging them actively in learning' was asserted by Ofsted (2004). Therefore, pupils can learn via meaning and personal relevance in their work, be it the work has some kind of interest to them or that they are motivated by improving grades and attaining qualifications. Where pupils have been innovative and productive when doing coursework, they have demonstrated the value of that work and are in many cases working actively towards completing and improving their work. An analysis of whether pupils would prefer to design their own coursework (section 6.8) brought mixed responses. Some pupils were enthusiastic, whereas others complained of not knowing what to do. While some learners like to innovate and maintain originality, others are less concerned with such issues and are more interested in completing their work with the least problems.

Constructivism touches upon the idea of interest and motivation in students how the life experiences of each pupil and teacher shape their ideas, their constructs. Knowledge is actively built up by the learner (Driver, Asoko, Leach, Mortimer and Scott 1994). Driver and Bell (1986) wrote that learning is an active process on the part of the learner and as such, a constructivist way of learning through science is also an active way of learning. It also resonates strongly with assessment for learning. So where pupils have been observed building new constructs, they have been learning actively to do so. Observational data results support the idea of a coursework based approach that allows pupils to work in a more constructive way than studying for examinations. Field notes from applied science students (section 4.7) provide further evidence that some students felt that they were being taught, and were learning constructively through science.

Observational analysis results show a greater degree of constructive learning in modular and applied science coursework lessons. Many pupils and teachers felt that they utilised assessment for learning techniques more readily in these subjects. Pupils generally seemed more ready to show their ideas and express what they had learned through their work than in examination studies. In the 2005/6 observations, pupils were more likely to show interest in new scientific ideas than apply them. By the 2007/8 observations applied science students were showing a greater difference in their degree of constructive learning between coursework and classwork than the other specifications. Classwork proved to be less constructive, possibly because the specification was set up more towards learning through coursework, and pupils adapted to this. Pupils and teachers may have put more effort into learning through coursework in applied science because the marks could be obtained beforehand rather than relying on examination performance on the day. Evidence from the pupil interviews (chapter five) showed that many pupils, across all of the specifications, indicated that they learned more through coursework than examinations. I would agree that, from my experience as a classroom teacher and researcher, constructive learning is a widely used and successful science teaching method in this study.

Teachers, when asked about assessment for learning in the classroom (e.g. pupil and peer assessment, teacher written and verbal feedback), which has much in common with constructivism, had mixed feelings (chapter seven). Some described of a lack of such opportunities in science 2006. Other teachers thought applied science gave assessment for learning opportunities but not science 2006, whilst others suggested that they gave AfL feedback comments, but pupils did not apply them to improve their work. Despite observational analysis that pupils were able to restructure their knowledge and take responsibility for their learning, some teachers did not feel that this was happening. Pupils studying applied, modular and separate science were more confident in using self, peer and teacher assessment to improve their work (as the QCA (2006d) claimed to be a part of AfL) than their science 2006 counterparts. This could be due to the nature of the science 2006 coursework, which cannot be revisited and improved and does not lend itself as well to assessment for learning techniques. It led to more science 2006 pupils forming negative views of coursework. Despite having stated that they learned more through coursework, science 2006 pupils in 2006/7 and 2007/8 were likely to have a negative opinion of science coursework, with some in 2006/7 describing it as 'bad' or comparing coursework unfavourably with the greater percentage of marks available for exams, and others in 2007/8 expressing similar sentiments, although one group pointed out how the examined science 2006 coursework can help them prepare for examinations.

In some observational analyses including modular science in 2005/6 and separate sciences in 2007/8, pupils were more likely to elicit scientific ideas and show interest in the lessons, than they did in applying new scientific knowledge. This can be linked to the statistically worse examination than coursework scores highlighted in section 10.3.2., which shows that pupils have been less successful in applying their new knowledge in examinations than through coursework.

In other observational analyses, including applied science and separate science in 2007/8, a large number of pupils were better at having new ideas elicited than they were at applying them in coursework lessons. However by the time they had finished their coursework many had applied enough new scientific information to achieve, for them, excellent grades. It would seem that applying new ideas takes place over a longer time frame than a few lessons.

Alongside this, in 2006/7 and 2007/8 more applied science students agreed in questionnaires that they preferred a coursework based approach. This was borne out in observational data with a greater degree of elicitation and restructuring of ideas through coursework than exam study. However, many of this cohort were unsure or disagreed that they enjoyed the coursework than enjoyed it. With this in mind, it could be argued that by making coursework more interesting and relevant, more students would actively learn and build new constructs. As I discussed in chapter 2.4.6 there are a myriad of theories, as individual as each learner, as to how to motivate them. There is not one specific way of motivating all of the pupils all of the time, so an approach such as that of coursework covering aspects of the science curricula, as used in applied science would seem an effective way of motivating learners, as they can see their grade improve as they actively improve their work. When questioned, some pupils agreed with this:

> 'Yes, yes, it [seeing my grades improve] means I'm doing better, and I can carry on doing better' (S1C8P16 19/06/2007)

Teachers should help pupils to make sense of how knowledge can be generated and validated, according to Driver, Asoko, Leach, Mortimer and Scott (1994). In this study, some teachers tended to indicate that they used a constructivist approach in the classroom, particularly in coursework lessons planned over a long period of time, such as a term, where pupil ideas and misconceptions helped to mould the individual lessons and the long term planning, although others admitted to teaching in a more positivist way 'the facts' for pupils to pass exams (section 7.11).

Two teachers in the 2007/8 questionnaire declined to comment to any questions about constructivism. Research undertaken by Halai and McNicholl (2000) found that many science teachers were not aware of what science is. Many teachers held views, such as that science is theory based and value free, and that the scientific method provides objective truth. The former view, they declared, is not compatible with a constructivist outlook on science education. Perhaps the interviewees were unaware of what constructivism is, or felt unconfident in speaking about the concept. Field note evidence from questioning teachers as to what constructivism (chapter 7.4) revealed that the five teachers I questioned admitted to not knowing what constructivism is. Despite this, observational analysis (chapter six) revealed that pupils were having their ideas elicited, and replaced by scientific constructs, which would indicate that they are being taught, and are learning, in a constructivist way, consummate with Reiss's (1993) summary of constructivist learning. This is limited evidence from which to draw conclusions about teacher knowledge about constructivism. It is a topic that would require further, and more substantial, research.

The constructivist approach in secondary science does seem to allow for individual thinking in that the ideas each pupil has built, which may have served them well outside of the classroom, can be elicited and discussed (Reiss 1993). Teachers in McNally's (2000) study pinpointed this, giving an example of pupils learning how to fix broken car engines, without using scientific constructs learned at school. This is the idea of pupils having a 'life world' and a 'school world' (Littledyke 1998).

The idea is that pupil ideas are replaced by more scientific constructs, if needed. This shows a less individual way of thinking whereby all are being told to think certain truisms inherent in science at GCSE level in order to pass examinations. There is no room at this level for individual ideas that contravene what is allowed on a GCSE exam paper.

Reiss (1993) pointed out how the assumption 'is that pupils need their ideas to be replaced with more scientific ones' (p.39), I believe that ideas are as closely homogenised in examination teaching and learning as coursework where pupils must also present theories and conclusions in certain ways to obtain marks. Teachers, when asked of constructivism in their own practice had mixed views. Some used pupil ideas to start lessons or to identify misconceptions and plan their teaching. Others said they did not, or would not comment. Naylor and Keogh (2007) described how teachers had little imagination when attempting to take pupil ideas into account, especially with large, often unenthusiastic classes. When asked about whether pupils gain a meaningful understanding of science, or they use science outside of the lab, those that responded pointed out that it was only motivated or high ability pupils that did. There were contrasting views on whether coursework or examination study gave a better understanding of the world.

Undergraduates tended to forget what they learned when studying for exams in comparison to when completing coursework (Gibbs and Simpson 2004). This could mean that coursework makes more meaningful constructs for them. Littledyke (1998) wrote of home and school lives in a positivist paradigm where pupils at school learned what they needed to satisfy teachers and exams and believed what they learned outside of school as it was more meaningful. Jenkins (2004) wrote that GCSE science is not relevant to the science that pupils encounter in their daily lives. A pupil and a teacher forget that what the pupil sees conveys no information until he knows beforehand the kind of thing he is expected to see, according to Medawar (1982). 'Pupils are experiencing a divorce of science investigations from learning' stated Toplis and Cleaves (2006 p. 77). Therefore, coursework based learning or exam based learning where meaningful constructs are emphasised could lead to longer term more effective learning, in preference to an attitude inherent in some pupils that emphasises the futility of learning science, as it has no use or meaning to them. Goldsworthy (2006) and Fox (2006) wrote of the relevance of school science, considering how it should equip pupils with the problem solving skills needed in later life. In Gott and Johnson's (1999) table of curriculum content instrumental understanding was the term they gave to this level of understanding. This reflects these everyday skills that they considered all pupils should in some way be taking from their science. Some pupils did not agree with this: In the Science Museum of London survey (2002), over half of the students asked felt that (pre applied and science 2006) GCSE science tested memory more than understanding. Field note evidence (section 5.7 pupil questionnaire conclusions) found some pupils espousing the use of what they had learned through science, whilst others thought their science was of no use to them.

Some pupils learned through discovering or being told the errors and deficiencies in their work so that they could improve it against the specification of grades for that piece of work and improve their grades. Field note questioning found evidence that some pupils preferred this approach (section 5.7). This is evidence that where pupils were given coursework improvement sheets, indicating where they needed to improve their work (appendix 12), they very often did so. This use of assessment for learning could be interpreted as part of Littledyke's (1998) theory of the positivist school paradigm and in some cases I believe pupils did improve only to satisfy teachers and exams, as a form of extrinsic motivation detailed by Harlen (2004) and the Research Synthesis Group research (2006). Field note evidence (section 6.4) found some pupils describing how they completed coursework for extrinsic goals such as rewards from parents, and examination grades.

The use of feedback sheets as assessment for learning corroborate with the application of Popper's theory about learning in science through discovering and eliminating mistaken ideas as considered by Swann and Pratt (1999). Popper viewed learning as the discovery of error and inadequacy in existing theories or expectations, 'Our task as learners is to discover and eliminate our mistaken ideas, and modify and develop those which are inadequate' (Swann and Pratt 1999 p.8). However, the feedback given on how to improve should be non-judgemental, according to Harlen (2004) who reasoned that this helped boost pupil attainment.

The rationale behind assessment for learning is to promote learning and teaching through feedback (Black and Williams 1998). It is formative, meaning that it should facilitate learning, rather than be measured through examinations and coursework grades at the end of the learning process (Brookes and Trough 2006). Harlen (2004) claimed that AfL can reduce the pressure on teachers and students from external tests and examinations and give teachers greater freedom to pursue and assess their own goals. However, as Hargreaves (2005) pointed out, summative assessment, in the form of tests and exams, dominates the education system. The public accountability of teachers and schools, particularly since the advent of league tables (Russell 1996) and performance management of teachers based on summative results have lead to pressure for teachers and pupils to achieve increasingly good results. Thus, the effectiveness of assessment for learning, despite being a tool for formative assessment, will tend to be measured in terms of summative examination and coursework grades. Black and Williams (1998) measured the effectiveness of AfL in the classroom in terms of attainment in examinations, as did McDonald and Bould (2003). Assessment for learning is to promote learning, which is measured in attainment through examination grades.

Alongside the ideas above, the deadlines and the volume of coursework pupils have to do can constrain the opportunities for active learning and constructivism as pupils and their teachers strive to ensure work is completed to exacting standards. Many pupils worried about time constraints having a detrimental effect on their work, according to Toplis and Cleaves (2006), and field note interviews garnered similar viewpoints from students (section 4.7). Poor time management may have contributed to these viewpoints. From my experience, a number of students at GCSE level are not effective at managing time effectively, and struggle to meet coursework deadlines. The volume of coursework across the curriculum, although being reduced, could also have contributed to pupil claims of excessive workloads. A number of teachers, in a National Endowment for Science, Technology and the Arts (2006) survey, also reasoned that a lack of time was the main constraint in teaching coursework.

The science 2006 specification should allow teachers to start 'reclaiming investigation for science learning by teaching science through investigation' (Toplis and Cleaves 2006, p.82). 79% of pupils claimed that practical work helped them in their understanding of science according to The Science Museum of London (2006). Experimental work in science can therefore be an aid to this. Evidence from field notes (section 5.11) suggests that some pupils believe they do have enough experimental work.

To make coursework more interesting and relevant for pupils the Popperian ideas of Swann and Pratt (1999) and the behaviourist methods of Woolnough (1994) could be combined. Pupils would be given a mark scheme where they are informed they will be marked on the quality of their planning, procedure, results and conclusions. They would be then free to choose a topic relevant or interesting to themselves, thereby giving their work meaning and motivation. This could alleviate the problem of what is relevant to pupils, highlighted by Ponchaud (2006), and allow pupils to develop the analytical and questioning skills espoused by Goldsworthy (2006) as what relevance really is. It would also help to alleviate the problem of many pieces of work being completed in very similar fashion, but would make the marking and setting of work more complex. However, many pupils may not be able to set their own experiment and many teachers may not be willing to monitor and assess many different projects going on in their lab.

Homework was said to have a minimal positive bearing on pupil attainment (Hallam 2004, British Educational Research Council (2006). I believe this research could help support keeping coursework in the lab and away from home. With the science 2006 coursework approach, this is achieved anyway. Higher order thinking skills revision for exam study should be given as homework to boost the attainment of the more able learners noted by Hallam (2004). For the less scientifically inclined, examination based skills, such as past paper questions can be given as homework, thus preparing them for the prescribed truths they must know in examinations. This implies a positivist tendency in examinations, which depending on how pupils are taught, can be true. Children can be taught in a positivist way a set of theories and ideas in science which they must recall to achieve marks. A colleague in the 2007/8 teacher interview remarked how it was difficult to fit in teaching of anything *except* examination theory. However, teaching pupils through constructivist methods can also achieve good results, and develop more critical, analytical thinkers able to interpret results and graphs, which is a component of examinations. Alongside this, the recall and application of ideas helps to assess the *level* of application of ideas as Gott and Duggan (1999) described when writing of the ability to apply instrumental understanding – knowing how a scientific phenomena occurs. The highest level of thinking, fundamental understanding and application is when the fundamental ideas of science are understood and applied in experimental situations. Examinations include means of testing these skills, alongside the analysis of results and investigations, without interference from others. So, despite a somewhat positivist slant to examination study, it can still be a useful means of assessing the level and application of a pupil's scientific thinking.

9.3.4 Research question 4: How effective, in terms of attainment of examination grades, is GCSE assessed science coursework for pupils' learning within the National Curriculum?

Coursework represents more accurately how people learn outside of the classroom according to AQA (2007). Team building and collaborative skills are developed through coursework in a way that thinking and writing for two to three hours, which rarely happens outside of examinations does not extend (AQA (2007). In many instances in this study, coursework results were significantly better than those for examinations.

Furthermore, coursework investigations are an essential part of science: A fundamental aspect of science is the investigative, inductive and in many cases empirical nature of the subject. Many interviewed pupils also claimed to learn better through such means. A lot of pupils also expressed the view that they preferred to learn through practical work. This has similarities with the Science Museum of London survey (2002) where 79% of students believed that practical and experimental work helped them to understand scientific topics as well as research by Nott and Wellington (1999), and Jones, Gott and Jarman (2000). To some, the two are synonymous. Coursework can also allow for a greater degree of active learning and there is observational evidence from learning approach analysis (chapter six) that pupils were more able to form new constructs from this form of learning.

However, pre-science 2006 coursework did not challenge many pupils to think scientifically. It encouraged rote learning, copying, and teaching to get grades rather than investigate. In this study, pupils studying modular and separate sciences were the only ones who generally got statistically higher grades at coursework than for classwork. Many teachers who delivered pre-science 2006 coursework in 2005/6 described it as building ability only in copying, and in one case described how they had to get them [the pupils] to do it and motivate them to do it. This clearly does not agree with a majority of pupils in this study who claimed they preferred coursework, even in the modular format, to examination study. Perhaps some pupils opined that coursework was the lesser of two evils. One applied science pupil certainly agreed:

> 'I'd choose coursework every time but I don't like either' (S1C2P9 25/04/2007)

Others expressed similar sentiments when questioned about their preference for coursework or classwork:

> 'I'd choose classwork. Coursework is worse 'cos no-one hardly does it' (S1C7P11 07/06/2007)

> '...coursework 'cos, I dunno, I have to listen for hours and hours and lose it. If you can do coursework at least you can do it yourself' (S1C7P8 07/06/2007)

Pre-science 2006 coursework did not teach pupils concepts of science. The knowledge taught was not extrapolated across anything other than the piece of coursework it was written on. The coursework topics selected generally reflected a select number of investigations which would give effective results that fit a pattern, such as the resistance of a wire, or the enzyme catalysed breakdown of hydrogen peroxide. Watson, Goldsworthy and Wood-Robinson (1999) and The House of Commons Science and Technology select committee on science education (14-19) (2002) came to similar conclusions, writing of a restricted set of investigations, including those mentioned above, that did not represent science.

Applied science, to some extent, exaggerated these problems with its greater emphasis on coursework, which can lead to more copying and rote learning in order to complete all of the work. A major problem with such a coursework oriented specification, is that when pupils have been absent for a long time, or transferred to a new school offering the specification, they are immediately under pressure to complete their coursework over a smaller time period. Some pupils did not find this to be a problem, such as one applied science student nearing the end of the course:

> 'I got all the coursework done ok after moving to applied science' (S1C2P10 25/04/2007)

Others I spoke to in a similar situation expressed similar sentiments.

The emphasis in pre-science 2006 coursework on obtaining anomalous results and improving the experimental method could be validated by Medawar (1982), who pointed out when talking of research science investigations 'too much is made of validation...a realistic methodology must be one that allows for repair'. This approach could be seen as validating the modular science mark scheme, which gave marks for anomalous results and improvements to the method.

Science 2006 coursework misses out a lot of the planning of a piece of coursework and can be open to criticism that it does not teach the skills required to plan, design, and evaluate an experiment. Schools should, if they could put their more scientifically academic pupils in single GCSE courses for the separate sciences (Times online 2007b). The less scientifically minded do science 2006 or applied science depending on their learning preferences. Lord Adonis (Times online 2006) also pointed this out.

In the Science Museum of London survey (2002), 60% of pupils felt that relating science to everyday life would help to improve GCSE grades in Science. A compulsory scientific literature core in the new science specifications, which should lead its learners to understand science in the media was discussed by Burden (2005a). Researchers, including Childs (2006) and Wright (2006), criticised the media for misrepresenting scientific news due to a lack of journalistic knowledge. The science 2006 / Jarvis & McClune (2005) approach could create a new generation of science aware journalists, or the next generation of scientific writers may inhabit a media driven world of sensationalism and misreporting, as Childs (2006) believes it does now. Maybe the ideas discussed by Wright (2006) about young scientific researchers confronting the media and creating a science friendly media in the future will be taken on board. We will see over the forthcoming years. Field note evidence from professionals involved with the delivery of science 2006 has not uncovered much evidence of a media driven science. Colleagues mentioned media based themes and other vague ideas, but there has been no teacher, myself included, in this research who was able to state that the new specification had demonstrated an approach that encompassed the media and science, as one colleague pointed out:

It [science 2006] is supposed to be related to the real world. It's as boring as anything, but that is the bread and butter of the marks, not the coursework' (SIT12 10/10/2007)

A concept for the future may be centres setting their own coursework to meet the interests and specialisms of staff and pupils and being assessed through different models to the mark-schemes set by exam boards. Teaching to the specialisms and interests of interests of teachers was opined to help motivate pupils learn about science outside of the lab (Pouchaud and Adey 1994). Realistically though, it would be difficult to ensure all were being completed to the same standard nationally, which could cause problems with the media and between centres.

Coursework with a reliance on proving facts goes against the idea of challenging paradigms and theories. Not all scientific 'facts' will remain so in the future. However, at GCSE level an effective piece of coursework is unlikely to challenges scientific norms. The notion of coursework proving facts could be challenged by using coursework to introduce new scientific ideas whereby pupils predict an outcome, and test to see if that outcome agrees with the prediction. If their prediction is proved wrong, a new scientific idea could be introduced to explain the phenomena. Thus through a piece of coursework new constructs could be assembled.

Mathematics GCSE and A level geography announced the cessation of coursework in the autumn of 2006 (BBC 2006e) citing internet plagiarism. However, if science coursework is researched, completed and written up in the science lab without being removed from that environment, this cuts out the option of using the internet or parents to complete it. This is reflected in the approach of science 2006, but science 2006 does not have any facility for pupils to improve their coursework using active learning, and in my opinion, represents a lost opportunity to develop a lab-based piece of work with scope for pupils to work actively to improve on a piece of work over time. Thus coursework represents, in the school of this study, a different, more active and constructive way of learning than through examination study. The movement from set experiments with known results, to investigations represents a shift from positivist to realistic science (Williams 2007). Coursework thus has a place in the science curriculum as, although it is not perfect, it touches in some way upon the ideas of scientific investigation and interpretation which are important skills for future scientists and for analysing situations and events across the curriculum and in life, far removed from science. If science can achieve this for its alumni then surely it can be described as an educational success.

9.4 Strengths and limitations of research methods

Despite the range of techniques I have used to collect and process data, my research is not free from limitations. I have pointed out issues relating to each research method in the relevant paragraphs, and how key gains were realised by using them.

Gorad and Taylor (2004) wrote of the strength of combining the qualitative and quantitative paradigms. I have been able to validate my findings by combining interview and observational data alongside questionnaires, field notes and quantitative calculations.

Possible problems with longitudinal studies include the large amounts of data that need to be processed, and analysing the data to produce a coherent report of change over time (Saldana 2003). However this data has added a richness and depth to the study, and has allowed me to assess the process of change and transition, and how people react to it, without the 'snapshot' effect of static data whereby the data may not explain the direction of change (DesJardins in Smart ed. 2003 p.426).

I was a full time teacher working with a lot of the pupils who have offered their opinions in interviews. They may have given answers particularly in interview situations to provoke a particular response from me, for example by praising coursework so I would give them a good mark. This compromise was worthwhile, as interview data has drawn upon the attitudes, feelings, beliefs, experiences and reactions of pupils in a way in which would not be possible using other methods, for example observation, one-to-one interviewing, or questionnaire surveys (Gibbs 1997).

Classroom observation is a common technique used to support interview data (Nespor 1987), yet as a full time teacher with curriculum to teach I have observed pupils but not as a non-participant observer who is free to spend all lesson simply watching without having to teach and intervene to maintain discipline. Even if I were able to observe pupils with a colleague, I would only have done so very intermittently and my presence would have distorted the data, and that students may well have exhibited some sort of Hawthorne effect, whereby pupils behave differently, knowing that myself, as a teacher, and participant observer, is observing them. However, such analysis has given me some important data, particularly to respond to research question three. Teachers can gain a lot of information by observing pupils taking part in activities (Littledyke 1998). As a participant observer, I have used my experience to shape and guide the research process and add data and opinions.

As I did not teach every class that participated in this research, I was not aware of local contexts in all of the classes that had submitted questionnaires. Informal knowledge that is specific, localised and relevant to the situation is an advantage here, as Bright (1995) wrote. He also stated that as a practitioner of research I must accept 'the possibility of errors in understanding and interpretation of situations' and that the idea of researching as reflective practice 'is to improve practice which must imply the possible presence of current errors' (p.77). None of this research has error free results but the results are substantial and worthy of extrapolation and analysis.

I did, as Homan (1991) pointed out, obtain approval from senior colleagues (and pupils) for my method of observation. Homan (1991) lists reasons against covert research, including that it flouts the philosophy of informed consent and erodes the liberty of those studied. I must point out that in education teachers are regularly asked to observe and make judgements on their pupils for reports, assessment data etc. However, my research was in no way deceptive or covert, and if pupils were to ask what I was doing I would happily tell them.

I collected, collated and analysed all of the questionnaire, interview, observation and quantitative data myself. Therefore, there was a chance of human error in these processes. My individual observational style may have shown in the data. Having participant thesis supervisors who could check and validate my data counteracted such effects.

My questionnaires were mostly completed by pupils at the school where I was employed, with additional data from one other school in the local area. The teacher interview section included respondents from four schools in the local area, with the majority from the school where I was employed. The pupil interviews and observations and the exam results analysis came solely from the school in which I was employed. There is a possibility that data from one establishment may have been a result of specific circumstances, such as a change of staff, or catchment area, which did not reflect the trends within other schools in the area and in the country as a whole. This research is a case study with a focus on one school, and drawing on complementary data from local schools. Case studies can be valuable in that 'it [case study] is expected in some way to be typical of something more general. 'The focus is the issue rather than the case itself' (Bassey 1999 p.62). The inclusion of information from other schools has provided the research with an additional quantity and range of data, particularly in the teacher interviews, where there were few interviewees in the case study school.

The data derived for this research was drawn mostly from one educational establishment, alongside complementary data from another school, and as such may not necessarily be generalised or applied across the secondary educational system in this country. Libarkin and Kurdziel (2002a) wrote of how a case study in a small setting such as mine will have only a limited range of circumstances to which any conclusions will apply. However, as a case study it was layered over many years and consists of a great deal of varied qualitative and quantitative data. Case studies provide what Libarkin and Kurdziel (2002a) described; 'new insights that are quite different from those generated by broader studies' (p.196). Other researchers, including Cohen, Manion and Morrison (2000) write of external validity and whether the results of a case study can be generalised to the wider population. The detailed focus obtained from this study provides a depth of data and analysis perhaps unattainable across broader studies and with the absence of any existing broader study encompassing the change of science curricula, the study provides an insight as to the attitudes, perceptions and results of stakeholders in the change. There are results from this study that corroborate other, broader based studies. For example, throughout the study, a large number of pupils agreed that they learned better through a practical, coursework-based approach. This agrees with a Science Museum of London survey in 2002 in which 79% of students believed that practical and experimental work helped them to understand scientific topics.

Throughout the duration of this study, the population from which data has been taken has changed, as have class sizes, and number of students studying different specifications, and numbers of pupils volunteering to fill in questionnaires. As a rule, a sample (which is a subset of a population (Colwell 2006)) should be as large as possible to increase accuracy and show characteristics of the population, rather than specific individuals (Powell 1979, Cohen, Manion and Morrison 2000). Therefore, a smaller sample may show more of the variation inherent in specific individuals, rather than the pattern across the entire population. Sampling error can come from the random selection of individuals who do not fit the mean of the population.

A study should have enough data to determine statistical significance where needed (Lenth 2001). The minimum number of participants for statistical analysis is deemed to be 30 (Cohen, Manion and Morrison 2000), but for purposes of investigating complex processes and views a closer focus on a limited sample may be most appropriate. Where sample sizes vary, broadening the scope of the study, to include different forms of data, make the results more applicable (Lenth 2001). By incorporating interviews and questionnaire data alongside statistical analysis, broadening the scope has been achieved in this study.

My work concentrated on teaching and learning using specific specifications given by the exam board Assessment and Qualifications Alliance, which all of the schools involved in this study used. There were alternative specifications produced by different exam boards, which delineate the National Curriculum differently. This may have some affect on pupil motivation and results. As long as the National Curriculum exists there are few differences in what is taught, just how and when. This of course also applies to individual teachers and their schemes of work and teaching styles.

When conducting interviews and analysing the data, I was not sure I had reached theoretical saturation, whereby no new different data, or categories of data emerged to any of my interview questions (Cohen Manion and Morrison 2000). I was constrained in that I had limited numbers of students and teachers to interview, and I could not be certain that more interviewees would not produce new, relevant data. However, as the research was case study based, I was still able to provide new insights (Libarkin and Kurdziel 2002a) and interpret findings from my interviews without broadening my study to obtain theoretical saturation which would compromise the advantages of a case study detailed above and in section 3.4.

There is a possibility that the findings I have uncovered in this research may be affected by a temporal perception issue; in that coursework was an immediate concern for pupils, whereas examinations were in the future. However, in modular and separate science, pupils sat six multiple choice examinations through the first year of their course (section 2.2.4), and some resat those examinations in their second year. Applied science students took an examination in the January and the June of their final year (section 2.2.5). Science 2006 students took examinations in the November, January, and June of their course (section 2.2.6). I collected interview and questionnaire data between January and July of each academic year (section 3.2) at a time where pupils were facing or had just sat examinations, depending on the specification, and also had coursework deadlines to meet. Therefore I collected data at a time when pupils perceived examinations and coursework to be important, immediate concerns, to lesson any temporal perception effect.

9.5 Reflexivity in the research process

Reflexivity concerns the mutual interdependence between an account of a social setting and the setting itself (Cohen, Manion and Morrison 2000). By applying this to my research I have found that completing the thesis has shaped and moulded my views concerning teaching and learning and science. Before commencing, I considered that science was a purely empirical undertaking and that learning was more of a positivist ideal where children were fed the 'correct' information in order to pass examinations. As a teacher and then a teacher/researcher I have delved into the ideas and assumptions underpinning my job rather than accepting it for what it is.

By researching constructivism and active learning alongside considering ideas about the nature of science itself I have developed a more constructivist outlook. I believe in the personal, individual nature of learning and that each person constructs their own view of the world, which is reflected in our construction of meaningful understanding of phenomena. I am more aware of the contested and changing nature of current thought about science. I believe in challenging and questioning ideas and I consider this to be an essential part of developing one's own idea of the world, be it the individual a researcher, teacher or pupil. By completing this research, not only have I answered research questions using empirical data as evidence, I have also opened my mind to the changing nature of ideas, and how individuals learn and make sense of them.

Furthermore, completing this thesis helped me to improve my professional knowledge concerning research methodology. I have gained valuable experience about assembling a research project and combining the qualitative and quantitative paradigms. I have developed techniques in compiling field notes, interviewing and developing questionnaires and quantitative methods. This will prove invaluable in shaping any future research that I undertake.

As a teacher involved teaching GCSE science, a primary reason for conducting the study was to establish the strengths and weaknesses of GCSE science coursework and examination study. By doing so I was able to adjust my teaching and inform colleagues of my findings in order to deliver the most effective science courses, as a catalyst to improving science education through effective teaching and learning where I worked. As well as this, as no evaluation of the new science courses has yet been completed, this thesis provides a case study focused on one school, and bolstered with complementary data from local schools, with an indication of the impact and implications of new science courses on teaching and learning at GCSE level.

9.6 Suggestions for future research

I am conscious that this thesis has concentrated on the results from one school with supporting data from other schools and I expanded on this in the limitations to research methodologies section. To gain an idea of the picture nationally the questionnaires, observations and interviews could be implemented in a representative sample of schools throughout the nation – but this is only possible for a large scale project with substantial financial and personnel support.

Other courses such as entry level have been offered as an alternative to GCSE science or applied science. The remit of this research has been GCSE science. To study entry-level science courses such as BTEC applied science, which is a practical coursework-based qualification, would provide a counterpart to this study and allow for comparisons in terms of pupil and teacher perceptions and attitudes. The same could be said for comparing specifications from different exam boards, of which there are many for science 2006 and applied science, to investigate if this causes some differences in attainment.

In researching the topic of coursework and collusion, I found very little literature concerning collusion and cheating in GCSE coursework. Most research has been based on higher education, or in the USA. This would be an area where further research could be undertaken.

Field note evidence from questioning teachers as to what constructivism is (chapter seven) revealed that the five teachers I questioned admitted to not knowing what constructivism is. This is limited evidence from which to draw conclusions about teacher knowledge about constructivism. It is a topic which would benefit from further, and more substantial, research.

Analysis in this thesis indicated that, in this study, ability, and being able to concentrate on, and improve a small amount of coursework led to better grades at that coursework. A lack of extant literature on this topic would indicate that further, and more extensive research would be needed to determine whether this is a localised, study specific conclusion, or one that has wider applicability.

The statistical data from this research uncovered little difference between boys and girls attainment in coursework and examination results in science. This suggests that separate boys and girls classes, or strategies for improving the results of one sex may not be needed, at least in GCSE science in the school of this study. Further research comparing these results to attainment in single sex classes would help to prove the validity of this statement. A finding from Elwood (1999) was that although boys scored less at coursework, there was more spread amongst their marks, which led to coursework having more of an effect on their overall grades. As an addition to this study, an analysis of the range of boys and girls coursework results may determine whether Elwood's (1999) findings are applicable to the newer specifications of applied science, separate sciences and science 2006 this study.

9.7 Concluding remarks

My research was conducted as a longitudinal, mixed methods practitioner based case study. This research was undertaken at a secondary school in England, with supporting data from other schools. I was conscious that there was no existing project that examined coursework and examination study in this way. The thesis coincided with a change in the science curriculum with the advent of science 2006 and the establishment of applied science as a vocational alternative. The thesis provided an opportunity for pupils and teachers to voice their opinions about the changes. Benyon (1985) highlighted a lack of emphasis concerning pupil opinions in educational research.

Through completing the review of literature, I identified four themes. These have formed the basis of my research questions and the resulting methods and methodologies I employed to gather data. The conclusions to each theme are detailed in the following section.

I identified the theme of the perceptions and attitudes of pupils and teachers to coursework in the review of literature. Through researching this, I have concluded that in this study:

- Pupils generally preferred coursework to exams, although many were not sure if they like doing it. Overall many pupils thought that they worked quite hard and got stressed by completing coursework, but not as much as they tended to for exams. More girls were stressed than boys over exams and coursework than boys. Most pupils thought that they received enough coursework, although by 2007/8 more were unsure of this, and they felt that they learned, and achieved more by doing coursework than by studying for examinations. Many pupils felt that they learned most through experiments and practical work. A number of teachers believed that pupils were helped too much in order to complete some pieces of coursework. Many pupils spoke of the benefits of coursework whilst bemoaning the workload and lack of interest they had in it. They became happier with assessment for learning in coursework through the duration of this study. Some teachers did not welcome the coursework section of science 2006 which they found difficult to mark and for pupils to improve upon.

I identified the above theme a gap in the literature. The above findings provide a knowledge base to attempt to counter that gap. They provide original evidence of the attitudes and perceptions of teachers and pupils towards coursework in a changing science curriculum.

A second theme identified this study were the variations in attainment between GCSE examination and coursework study, including differences between boys and girls coursework and examination grades. Through research, I have found that in this study:

- There were very slight differences between girls and boys exam and coursework grades but they were not significant, although boys exam results for science 2006 were higher than girls in 2007/8 and this was close to the critical figure for statistical significance. Coursework grades in modular and separate sciences were superior, in many cases significantly, to exam grades. This situation was reversed with science 2006. Applied science coursework grades were generally higher than those for exams, but not statistically so.

The above findings are evidence that in this study boys and girls did not have significantly different coursework and examination grades. This is a major finding indicating that perceived differences between boys and girls coursework grades may not be evident. Where coursework can be reviewed and improved, pupils can get significantly better grades. This is original evidence for the retention of coursework where assessment for learning can be applied. Both of these findings help to bridge the gap in the literature that I identified.

The third theme I identified was to ascertain how pupils learn through completing their coursework. Within this were the concepts of constructivism, active learning and assessment for learning. By researching this, I have uncovered that in this study:

- Many pupils spoke positively of the science they have learned through constructivism. Coursework based lessons tended to produce more active learning, expressive, productive, innovative and constructive work amongst most pupils. The differences were generally more pronounced in modular than applied science pupils. For science 2006 in 2007/8 pupils tended to learn more constructively through classwork. For exam study, in general, pupils displayed less scope for teamwork, innovation, flexibility and constructive learning. There was an emphasis on learning for one's self rather than sharing results and working together to process conclusions. Many applied, modular and separate science students felt able to apply assessment for learning to their work. Many science 2006 counterparts felt unable to.

The above findings have provided an original insight into the role of active learning, assessment for learning, and constructivism within GCSE science coursework and classwork. By doing so this thesis has helped to develop the literature in this field.

The final theme was the overall effectiveness of coursework in GCSE science, in terms of examination grades. My main finding is that in this study:

- Coursework investigations are an essential part of science education. Many pupils, including those studying science 2006, where the coursework cannot be assessed and improved on preferred coursework to exam work. In the courses where more pupils have indicated that they can improve their coursework, and where coursework does not make up a majority of the marks for the specification, there have been significantly higher coursework marks than those for examinations, in the main school of this study. In these courses, pupils were generally more able to use assessment for learning and active learning, and they learned more constructively. The modular and separate coursework, where pupils could assess and improve their grades encouraged rote learning and copying, although pupils achieved statistically significantly higher coursework grades than for examination by doing it. Pupils achieved significantly lower grades for coursework than examination in science 2006 coursework, which cannot be assessed and improved upon.

This finding is evidence that coursework in GCSE science, where it can be reviewed and improved, can be effective in improving attainment through final GCSE grades. However the format of that coursework needs to be developed so that it does not encourage rote learning and copying, but instead encourages assessment for learning, active learning and learning through constructivism.

Through identifying, researching, discussing and concluding the themes of this thesis, my research has helped to widen the literature in the area of coursework in GCSE science education. I believe that no such practitioner enquiry has yet been undertaken, making this study an original insight, which is backed up by Gadd's (2004) assertion that no formal evaluation of the coursework-based applied science GCSE had yet been undertaken.

These findings represent a unique critique of the impact of different science specifications, and a comparison between coursework and exam based study on pupil performance and attitudes, and teacher attitudes. The opinions, thoughts and ideas I have reported on may be shared by those involved in education in other institutions more widely. The findings 'fit' into a bigger picture of change in the science curriculum, indicating how pupils and teachers at one establishment have responded to these changes.

Thus, the findings this thesis have uncovered will be of use to teaching colleagues including those with responsibilities for selecting which GCSE courses to operate, researchers looking at assessment for learning in science, specification designers and last but not least to myself.

Teachers can use the findings to justify the science they teach or to press for changes to the specifications they teach in order to maximize the learning of their students, as can those with responsibilities for selecting the specifications. I have used the findings to improve my own teaching; to act upon what pupils and colleagues have said and how pupils may learn, in order to teach more effectively.

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Appendices

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Appendix 1: Pupil coursework questionnaire

* Question seven was added in the 2006/7 questionnaire to assess pupil use of assessment for learning

Coursework Questionnaire:

There are 5 questions, each with 3 choices: agree, not sure, and disagree.

Take your time and decide which answer to put and circle the correct word.

I am MALE FEMALE

I study APPLIED SCIENCE	SCIENCE 2006	SINGLE SCIENCE	SEPERATE SCIENCES

1) I prefer doing coursework to exams?

Agree not sure Disagree

2) I have enjoyed doing the Science coursework?

Agree not sure Disagree

3) I work hard in coursework lessons?

Agree not sure Disagree

4) I get stressed about coursework?

Agree not sure Disagree

5) I get stressed about exams?

Agree not sure Disagree

6) Do you think you get the right amount of coursework in all subjects?

Too little the right amount too much

7) Are you able to tell what grade your coursework is at and how to improve it?

Agree not sure Disagree

8) Any other comments about coursework?

____

Appendix 2: Whole afternoons / mornings coursework questionnaire

Coursework Questionnaire:

There are 5 questions, each with 3 choices: agree, not sure, and disagree.

Take your time and decide which answer to put and circle the correct word.

1) I prefer doing coursework to exams?

Agree not sure Disagree

2) I have enjoyed doing the Science coursework?

Agree not sure Disagree

3) I prefer doing coursework over a day e.g. at during exams week than over a series of lessons?

Agree not sure Disagree

4) Coursework over a day or morning is more interesting than in a series of 1 hour lessons?

Agree not sure Disagree

5) The coursework in exams week was more relevant than coursework done over many 1 hour lessons?

Agree not sure Disagree

6) Do you think you get the right amount of coursework in all subjects?

Too little the right amount too much

7) Any other comments about coursework?

Appendix 3: Sample completed pupil questionnaires

Coursework Questionnaire:

There are 5 questions, each with 3 choices: agree, not sure, and disagree.
Take your time and decide which answer to put and circle the correct word.

1) I prefer doing coursework to exams?

Agree not sure Disagree

2) I have enjoyed doing the Science coursework?

Agree not sure Disagree

I prefer doing coursework over a day e.g. at during exams week than over a series of lessons?

Agree not sure Disagree

Coursework over a day or morning is more interesting than in a series of 1 hour lessons?

Agree not sure Disagree

5) The coursework in exams week was more relevant than coursework done over many 1 hour lessons?

Agree not sure Disagree

6) Do you think you get the right amount of coursework in all subjects?

Too little the right amount not enough

Any other comments about coursework?

erm no

Coursework Questionnaire Academic year 2006-2007

Coursework Questionnaire:

There are 5 questions, each with 3 choices: agree, not sure, and disagree. Take your time and decide which answer to put and circle the correct word.

I am MALE FEMALE

I study APPLIED SCIENCE | SCIENCE 2006 | SINGLE SCIENCE | SEPERATE SCIENCES

1) I prefer doing coursework to exams?

Agree not sure Disagree

2) I have enjoyed doing the Science coursework?

Agree not sure Disagree

3) I work hard in coursework lessons?

Agree not sure Disagree

4) I get stressed about coursework?

Agree not sure Disagree

5) I get stressed about exams?

Agree not sure Disagree

6) Do you think you get the right amount of coursework in all subjects?

Too little the right amount too much

7) Are you able to tell what grade your coursework is at and how to improve it?

Agree not sure Disagree

8) Any other comments about coursework?

Prefer exams.

Coursework Questionnaire Academic year 2006-2007

Coursework Questionnaire:

There are 5 questions, each with 3 choices: agree, not sure, and disagree.

Take your time and decide which answer to put and circle the correct word.

I am		MALE	FEMALE	
I study	APPLIED SCIENCE	SCIENCE 2006	SINGLE SCIENCE	SEPERATE SCIENCES

1) I prefer doing coursework to exams?

Agree not sure Disagree

2) I have enjoyed doing the Science coursework?

Agree not sure Disagree

3) I work hard in coursework lessons?

Agree not sure Disagree

4) I get stressed about coursework?

Agree not sure Disagree

5) I get stressed about exams?

Agree not sure Disagree

6) Do you think you get the right amount of coursework in all subjects?

Too little the right amount too much

7) Are you able to tell what grade your coursework is at and how to improve it?

Agree not sure Disagree

8) Any other comments about coursework?

Appendix 4: Pupil interview sheet

* Question 5 was changed from 'Any other thoughts?' in 2005/6 to 'Are you able to complete your coursework to targets and assess it as you go?' for 2006/7 and 2007/8 to gain an understanding of whether pupils are able to apply assessment for learning.

Coursework Study – Group Interview
Date
Group
Subject

1) What do you think about coursework in Science?

2) Do you do better at coursework or exams?

3) How do you learn best in science?

4) Do you learn more by doing coursework or theory for exams?

5) Are you able to complete your coursework to targets and assess it as you go?

Appendix 5: Example completed pupil interview sheets

Coursework Study – Group Interview
Date Sum 06
Group 11S1
Subject MOD SC

3x

1) What do you think about coursework in Science?

easier than anything else
prefer exams

2) Do you do better at coursework or exams?

exams
c/wk

3) How do you learn best in science?

randomly!
revising + practicals

4) Do you learn more by doing coursework or theory for exams?

c/wk
theory

5) Any other thoughts?

/

Coursework Study – Group Interview
Date 06/04/07
Group 10x4
Subject Sci 2006

1) What do you think about coursework in Science?

Dont like it. x 2
It's not good doing the coursework, it is like exams but exams are better. They are worth more.

2) Do you do better at coursework or exams?

Coursework...
Coursework – better results
Coursework
Cwk x 4

3) How do you learn best in science?

I like doing practical work
doing experimental work is best
only 2 answers given – other dont know

4) Do you learn more by doing coursework or theory for exams?

Coursework I think
Yeah coursework definitely.
Coursework
all coursework

5) Are you able to complete your coursework to targets and assess it as you go?

Dunno
I dont know
Unsure.
Pupils indicated theyre unsure.

Coursework Study – Group Interview
Date 9/05/08
Group 11X2 APP SCI
Subject ↗

1) What do you think about coursework in Science?

It is better than tests - stress
It is crap
I like the demos why.
No opinion

2) Do you do better at coursework or exams?

Coursework definitely
Coursework.
Coursework cos you can improve on it.
Coursework

3) How do you learn best in science?

Posters I think
Demos.
Doing experiments
Experiments

4) Do you learn more by doing coursework or theory for exams?

Definitely coursework
Demos.
Coursework
Coursework

5) Are you able to complete your coursework to targets and assess it as you go?

Yes.
Yes I'm sure
Yes
Yes

unanimous result.
Pupils were sure of how to improve work & could give examples of

Appendix 6: Learning approaches observation form

EPIC classification system

Domains of learning dispositions Name of pupil:

Expressive

	L1	L2	L3	L4	L5
Confidence					
Curiosity					
Open-mindedness					
Responsiveness					

Productive

	L1	L2	L3	L4	L5
Exploratory					
Planning					
Applying					
Monitoring					

Innovative

	L1	L2	L3	L4	L5
Adventurous					
Flexibility					
Creativity					
Evaluating					

Constructive

	L1	L2	L3	L4	L5
Interest					
Eliciting ideas					
Restructuring					
Application					

L1 Reluctant to engage naturally, no exploratory activity, uses avoidance tactics
L2 Engagement is haphazard, exploratory activity not focused, easily distracted
L3 Engagement is hesitant, explorations routine, requires probing and prompting
L4 Engagement is more continuous, exploration more imaginative, interactive
L5 Engagement is continuous, open-ended and reasoned, autonomous and responsible

Appendix 7: Sample completed learning approaches form

EPIC classification system

Domains of learning dispositions **Name of pupil** KG

Expressive

	L1	L2	L3	L4	L5
Confidence					
Curiosity					
Open-mindedness					
Responsiveness					

Productive

	L1	L2	L3	L4	L5
Exploratory					
Planning					
Applying					
Monitoring					

	L1	L2	L3	L4	L5
Adventurous					
Flexibility					
Creativity					
Evaluating					

Collaborative

	L1	L2	L3	L4	L5
Interdependence					

Reluctant to engage naturally, no exploratory activity, uses avoidance tactics
Engagement is haphazard, exploratory activity not focused, easily distracted
Engagement is hesitant, explorations routine, requires probing and prompting
Engagement is more continuous, exploration more imaginative, interactive
Engagement is continuous, open-ended and reasoned, autonomous and responsible

Appendix 8: Interview sheet for teachers academic year 2005-6

Questions

1) How have you found the coursework experience this year in comparison with teaching for exams?

2) Do you think it builds pupil ability?

3) How much help did you end up giving them?

4) Do you think the coursework deadlines for different subjects should be more spread out?

5) How did you find marking and moderating it?

Appendix 9: Interview sheet for teachers - academic year 2006-7

Questions

1) How have you found the coursework experience this year in comparison with teaching for exams?

2) Do you think it builds pupil ability?

3) How much help did you end up giving them?

4) Do you think the coursework deadlines for different subjects should be more spread out?

5) How did you find marking and moderating it?

6) How have you found teaching how science works?

7) Do pupils have much opportunity to use AfL in their coursework?

Appendix 10: Interview sheet for teachers - academic year 2007-8

Questions

1) How have you found the coursework experience this year in comparison with teaching for exams?

2) Do you think it builds pupil ability?

3) How much help did you end up giving them?

4) Do you think the coursework deadlines for different subjects should be more spread out?

5) How did you find marking and moderating it?

6) How have you found teaching how science works?

7) Do pupils have much opportunity to use AfL in their coursework?

8) What use do you make of children's concepts and ideas of science?

9) Do exams and or coursework give pupils a meaningful understanding of science?

10) Do you think they use their science to understand the world outside the lab?

05/08

Sample interview for teachers involved with coursework:

Questions

1) How have you found the coursework experience this year in comparison with teaching for exams? Well I had to intervene ~~to get~~ lots for them otherwise they would not get the work finished or improved at all

2) Do you think it builds pupil ability?
No, doesn't end up teaching them art, just how to write up their c-work to hopefully [illegible]

3) How much help did you end up giving them?
Too much tend to do all.

4) Do you think the coursework deadlines for different subjects should be more spread out?
Yep.

5) How did you find marking and moderating it?
It's a ~~chore~~ chore to mark it all

W/S - 2007

Ɔı

Iow hav you found the coursework experience thi year in comparisc n with teaching for ·xams?

Crap - pointless copying & checks!

ɔu think it build pupil ability?

nope makes em jump though hoops

Iow much help did you end up giving them?

em a lot - applied not run properly

4) ɔo you think the coursework deadlines for different subjects should l

em yeah

How id you fir marking and moderating it?

boring & pointless. repetetive

Iow have you found teaching how science works?

em little snippets of real life sci otherwise boring

Do pupils have much opportunity to use AfL in their coursework?

none at all in Sci 2006

hat ıı ıke of children's concep

none at all!

ɔo exams and or coursework give pupils a meaningful understanding of science?

em its a bit of a benefit for Sci 2006 compared with previous

10) Do you think they use their science to understand the world outside the lab?

some do - the ones who bother to think outside the lab
· the clever ones
if they dont like it they dont use it

Questions

1) How have you found the coursework experience this year in comparison with teaching for exams?

A bit messy ~~too~~ as people are unsure when, where and who is doing the coursework.

2) Do you think it builds pupil ability?

Yes: they can learn practical techniques which are helpful if they want to proceed with their science further, to A level.

3) How much help did you end up giving them?

Yes – I give them a lot of chances to improve & I suggest improvements which they take on board & do.

4) Do you think the coursework deadlines for different subjects should be more spread out?

Yes – pupils have lots of diff deadlines to meet

5) How did you find marking and moderating it?

Generally ok.

6) How have you found teaching how science works?

Fine, I had no great probs with the science. It is hard to fit alongside the subject matter for the exams tho,

7) Do pupils have much opportunity to use AfL in their coursework?

Nope.

8) What use do you make of children's concepts and ideas of science?

Yes – to plan future teaching

9) Do exams and or coursework give pupils a meaningful understanding of science?

Coursework? depends on the motivation of the pupils

10) Do you think they use their science to understand the world outside the lab?

In some topics.

Appendix 12: Applied science improvement sheet

GCSE Applied Science
Feedback Sheet

NAME: GROUP:

TOPIC:

Date Marks Grade	
Date Marks Grade	
Date Marks Grade	

How to improve your marks	Tick when done
Date:	
Date:	

To be filled in by your teacher
Final Mark Awarded: ________/________ Date Completed: __/__/__
Signed____________________

Appendix 13: Single sex male applied science results 2006/7

(Pupil names have been removed and codes added in their place)

Name, pred. grade	Unit 1	Unit 3	Unit 2	Overall	Grade
P1 E	32	35	25	92	C
P2 D	30	32	19	81	D
P3 C	36	37	27	100	C
P4 E	32	33	29	94	C
P5 C	33	29	29	91	C